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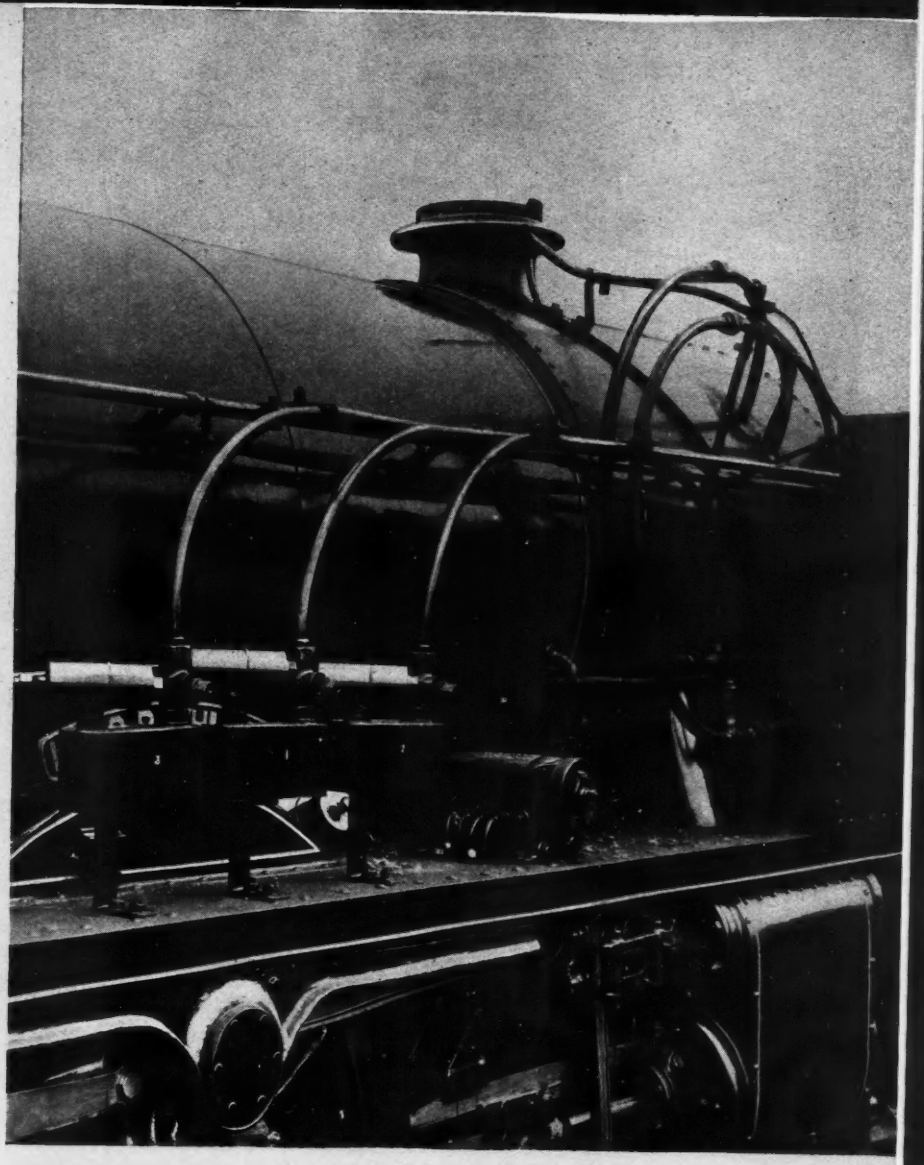

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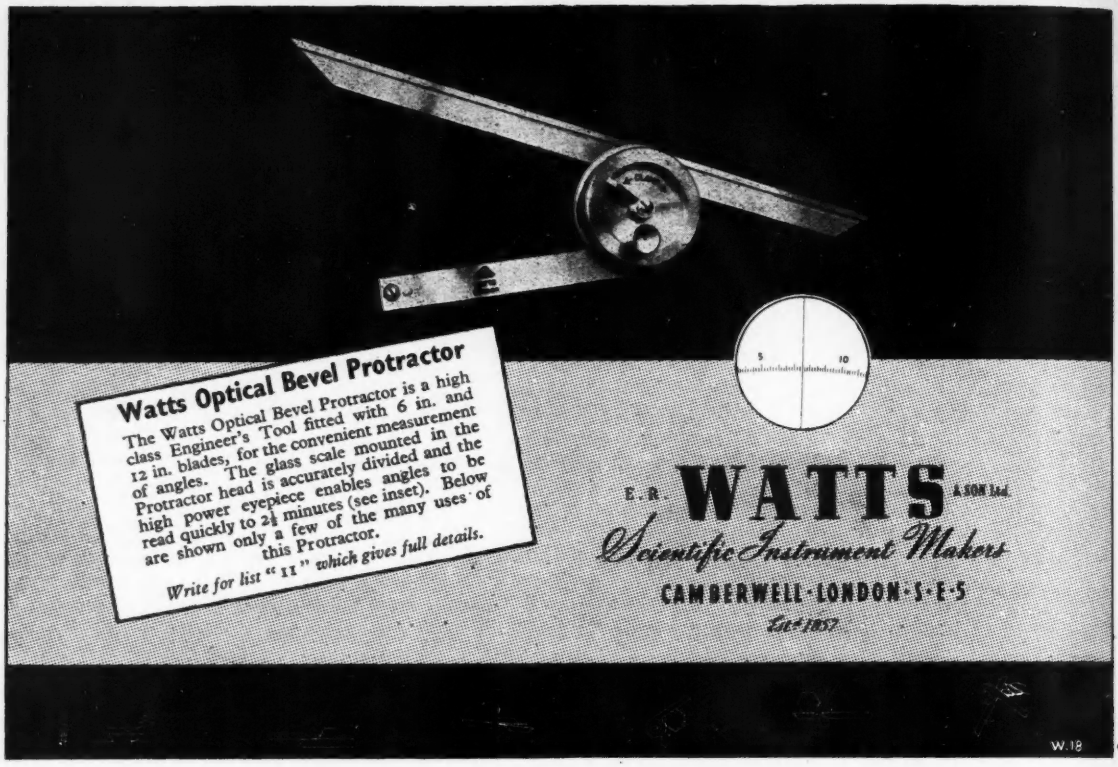
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DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

In Praise of Statistics

"THERE are lies, damned lies, and statistics," said the cynic, sacrificing truth for a witticism. In fact, the methods of statistics are an essential weapon in the armoury of science—a weapon which has been applied on all science fronts from the study of astronomical and atomic phenomena to biological and agricultural studies, as well as to the study of the behaviour of the social system in which we live.

To some extent the employment of the statistical method has indicated a drastic and fundamental change in our approach to scientific problems and in the nature of those problems and solutions to them which we are prepared to accept.

New sciences almost always begin as a system of classification, in which phenomena are classified into a variety of more or less distinct types, between which correlations may be observed. In the development of the exact sciences as recorded by history, the next step has been to apply quantitative ideas to the individual phenomenon or event, and those quantitative ideas have become more refined and more elaborate until it has been possible to make predictions of future events with a high degree of accuracy. Thus for example, astronomy, the earliest of the exact sciences, proceeded on the basis of the work of Tycho Brahe, Kepler, Galileo, Copernicus, Newton and their successors, to a theory of the solar system unparalleled in its elaboration and unequalled in the nice precision of its predictions. This became possible because the investigators were dealing with simple objects moving under the influence of a single set of simple laws of motion. It was possible to reach such an extraordinary degree of intensive development of the science because observational anomalies were due, not so much to a new multiplicity of causes, but because the same set of rules had not been applied with the necessary thoroughness. Positional astronomy therefore went ahead by leaps and bounds, enduing its creators with the confidence that only the physical difficulties of calculation to the necessary degree of accuracy stood between them and perfection.

However, long before astronomy had reached its peak of development other sciences were passing out of their botanical stage into the phase of quantitative development. For them causation was a less simple matter. The sequence, mathematics, astronomy, physics, chemistry, biology, sociology represents at once a passage from perfect precision to uncertainty, from simple causation to multiple causation, and from the inanimate to the animate. It also represents a sequence in which the methods of statistics play an ever important part, and is also (but only very roughly), the sequence of development to comparable levels of those sciences.

Statistics and their collection and analysis are the ideal method for the treatment of data in which the final result is produced not by the operation of a single or a few causes, but by the mutual interaction and summation of a great many causes, not all of which can even be enumerated in every case. It is the business of statistics to endeavour to offset the uncertainties resulting from multiple causation by the analysis not of a single result, but of many results obtained under conditions which are comparable. The claim for the efficacy of patulin as a cold cure cannot be made on a single result, since the course of a cold depends on a great variety of circumstances of which the physical condition, diet and resistance of the patient, his occupation and past history and his age are only a few. A single result—whether cure or failure—depends on all these factors, and it is impossible to disentangle from their complexity the influence produced by the administration of a drug. If, on the other hand, many cases are treated under similar circumstances, the percentage of cures may give an indication of the efficacy of the additional factor which the experimenter has introduced, and may enable the statistician to estimate the significance of the results.

Statistical methods are finding application not only in biological fields but to an increasing extent in the exact sciences. It is significant that the study of matter as a collection of atoms, molecules, and electrons renders it impossible and impracticable to study the behaviour of the individual particle, and thus the investigation of large numbers of entities has been pushed on by their study

en masse using statistical methods, some of which are borrowed from other statistical fields, while others are specially developed and find more extensive application later.

The techniques which the statistician uses for the disentangling of a definite trend from a multitude of random factors have in war-time proved of immense value in all fields, from the analysis of combat itself, to the maintenance of the production of essential manufactures. This latter application has led to the development of the system known as quality control, which consists in the continuous statistical examination of samples of the output as it comes from the lathe or milling machine. In the specification the tolerance allowed on a certain dimension may be, say, one-thousandth of an inch. The samples are measured with a much higher degree of precision, say twenty times, and by determining the variability of the dimensions of the component the statistician can see in advance when there is a tendency for undue variation to develop, and can check it before it grows so large that it exceeds tolerable limits and necessitates the scrapping of part of the product.

This is an example of the way in which the work of the statistician finds application to everyday life, where conditions cannot be controlled with the same accuracy that is possible in a laboratory experiment, and where the elucidation of all the many causes—in the given case they would include tool wear, lathe setting, fatigue of the worker, and so on—is neither possible nor indeed desirable.

A second example is suggested by the recent publication by the Medical Research Council of a memorandum on the epidemiology of diphtheria. By statistical analysis it has been possible in this case to disentangle the influence which has been exerted (for instance) by the introduction of diphtheria immunisation from all the many other causes which may influence the diphtheria mortality rate at any given time. It is to problems of the community—its fertility, death and disease rate, its physical and economic condition—that statistical methods are of essential application, and it is to such problems that they have been applied ever since Malthus made his studies on population.

It is here too that the abuse of statistics may arise, in the malicious or irresponsible interpretation of isolated or incorrect figures to maintain a social or political thesis. Examples are many, ranging from the ludicrous return by an Indian Army Medical Officer who stated that 50% of the teetotallers in his regiment had died during the year (the unfortunate man had been clawed by a tiger), to the more serious and important examples provided during this war by the controversies over air-raid protection for the public, and the specious statistical arguments advanced by the opponents of diphtheria immunisation.

Perhaps we should paraphrase the epigram and say, "There are lies, damned lies, and bad statistics" and condemn the last as the greatest offence against the well-being of the body politic and the possibility of social advance. For indeed, as we are reminded by the recent publication of the Royal Statistical Society on Official Statistics, almost all our information about our own society and its needs is couched necessarily in statistical form, and it is a matter of the highest importance that this information should be fairly and objectively interpreted. It is through the methods of the collection and analysis of statistics that we may hope to see applied to our own social system that sound scientific analysis without which it cannot advance. As the Royal Statistical Society's Memorandum emphasises, the old favourite Ministerial reply, "The information is not available" is just not good enough especially in war-time, and so there came into being the Central Statistical Office within the Offices of the War Cabinet. Such an organisation must obviously be continued for, in the words of the Memorandum, "It seems to us an inevitable social development that the State will intervene on an increasing scale in the life of the community in future years, and therefore that an increasing amount of information will have to be collected for Ministerial guidance. Even to-day it is possible to predict with some confidence that greatly increased information will be necessary to formulate plans for reconstruction and social improvement . . . We therefore take it as axiomatic that in future statistics will form an important constituent of the work of Government Departments." For scientists the most important requirement will be that there shall be no bad statistics, and they will applaud the more detailed discussions in the memorandum which call for the employment of properly qualified statistical experts, trained not only in mathematics but in economics as well, and with some experience of research or field work.

It is the statisticians whose work will in future bring the benefits of scientific advance closer to the community that needs them. It is they who will save us by pertinent and accurate information from the danger of the kind of planning in which unknown resources are matched to unknown needs. In society truth is not everything: it is the significance of statement that counts, and it is to the statisticians that we must look for the assessment of significance.

Black Death

In recent years great attention has been devoted to the useful substances produced by fungi during their growth. Typical of such products are penicillin, the powerful new anti-bacterial, and patulin, which has been used in the treatment of colds. Rather less is known of the poisonous substances which the fungi produce. Yet the activities of one simple fungus, known scientifically as *Claviceps purpurea*, have been responsible for centuries past for periodic outbreaks of a terrible and often fatal disease. *Claviceps purpurea* is a parasite which infects the ears of rye. Much less commonly wheat, barley and oats are attacked. The infection is always commonest after a warm damp summer, producing conditions under which most fungi thrive. At the time of harvest the infecting mould produces black pointed fruits which stick out from the stem among the glumes (or grains) in the ear of rye (see Fig. 1). These black fruits give the rye a characteristic "smutty" appearance.

The blackening of the rye is known as ergot and consumption of the infected grain gives rise to the disease now known as ergotism. The connection between ergot and ergotism was discovered in France in the middle of the seventeenth century, but controversy on the subject raged for a further 150 years. By the beginning of the nineteenth century however, it was generally recognised that ergot was a deadly poison and most of the governments of Europe enforced laws to ensure the destruction of infected crops.

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Ergotism can appear in two forms, known respectively as the gangrenous and the convulsive. The former is characterized by a swelling of the extremities of the body, followed by a blackening and mummification of the affected part. As a result the wretched sufferers may lose hands or feet or even whole limbs. Convulsive ergotism is characterized by more or less violent spasms of the muscles. In mild cases there is only an irritating twitching of the smaller muscles; in severe cases the limbs are rigidly and agonizingly flexed. Convulsive attacks may recur for weeks or even months. The mortality in ergotism is high and often exceeds 50%.

Since ergot rarely attacks crops other than rye it is not surprising that almost all the outbreaks of ergotism have occurred in countries where rye is a staple cereal. At present the chief of these countries are Germany, Poland, Russia and Scandinavia, though until comparatively recently much rye was eaten in France. In the past the disease has taken a heavy toll of human life. One of the earliest known outbreaks occurred in Lorraine in 994 when 40,000 people are said to have lost their lives. Another followed in 1039. At that time the disease was regarded as a sign of divine wrath for breaking the truce of God (which among other provisions restricted fighting to Mondays, Tuesdays and Wednesdays). By the same token an outbreak may be expected to-day in the rye-eating countries of Europe. This indeed is not unlikely, since in many war-devastated regions the peasants may be forced to rely on grain which would normally be rejected. In 1777 an outbreak in the Sologne area caused more than 8000 deaths. After this outbreak the cleaning or destruction of infected rye was more generally enforced, and improved methods of agriculture made ergot less common. Nevertheless, 11,000 cases were reported in an outbreak in Russia in 1926, resulting in 93 deaths. In this country, where little rye is grown, there have been few cases. A small outbreak which occurred in Norfolk in 1762 was traced to ergot-infected wheat. In 1928 some 200 mild cases of the convulsive type were reported in Manchester among refugees from central Europe who lived on rye bread.

In more ways than one ergot has a black record, and the occurrence of outbreaks within recent years shows that it has not yet been brought fully under control. The risk of European outbreaks under war-time conditions is considerable. Yet in spite of its destructive power modern medicine has found a use for ergot. Chemists have extracted the active principles, called ergotamine and ergotoxine, and these, together with crude extracts of ergot itself, have proved valuable drugs. Under various trade names, such as Gynergen, they are used extensively in obstetrics and for the relief of migraine. Indeed, so great is the annual demand—estimated at 250 tons—that the cultivation of the once-dreaded ergot is now a minor industry.

White Scourge

SYPHILIS is one of the venereal diseases, and if left untreated produces disablement and death. It is caused by a microscopic organism of a spiral shape, which is called a spirochaete. This organism is related to another group known as the trypanosomes, responsible for the deadly tropical disease known as sleeping sickness. Syphilis is

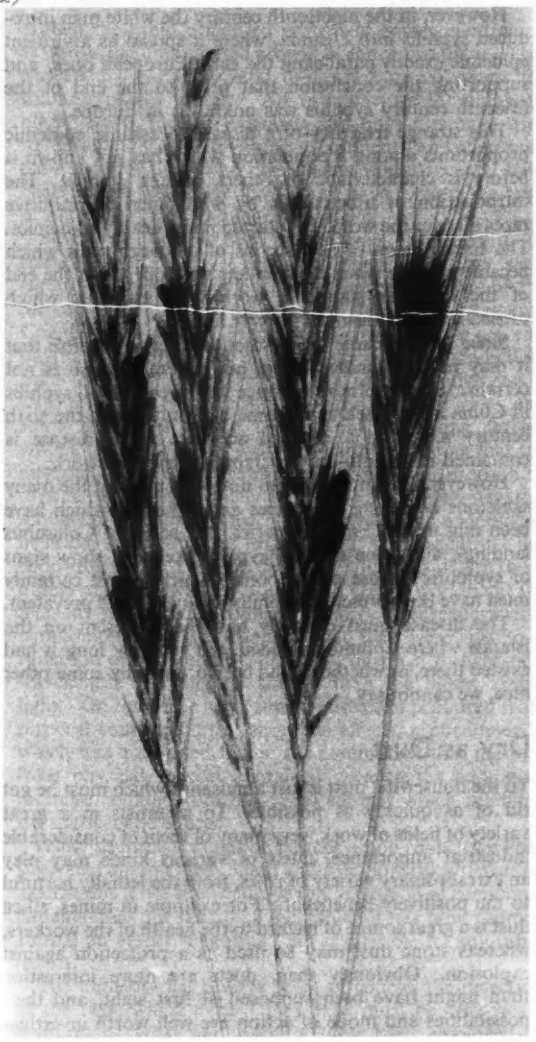


FIG. 1—Ergot in rye. Note the black spurs protruding between the grains in the ear.

widespread in the world to-day, but many authorities believe that it was unknown in Europe before the Middle Ages. At the end of the fifteenth century the disease appeared in the form of an epidemic, coinciding in time with the return of Columbus and his men from their voyage to America.

It appeared at the siege of Naples in 1495, and the armies of Charles VIII suffered severely from it. The violence and deadliness of the disease made this epidemic one of the most serious of the many which have ravaged Europe during the course of history. Its violence was such that for a long time medical men of later centuries, who knew syphilis as a deadly but slow and insidious disease, refused to believe that syphilis was really responsible for the epidemic.

However, in the nineteenth century the white man introduced syphilis into Uganda, where it spread as a virulent epidemic exactly paralleling the early European ones, and supporting the conclusion that prior to the end of the fifteenth century syphilis was unknown in Europe.

This strange tendency of a disease to assume epidemic proportions among a population which has not known it before is characteristic of others besides syphilis. The introduction of tuberculosis by white men to primitive races all over the world has started many deadly epidemics. The transmission of new strains of influenza virus which became possible when the frontiers were opened at the end of the last war started a world-wide epidemic which caused more deaths than the war itself.

Since syphilis came from America it seems possible that it may have originated there, but its exact origin is not certain. Some authorities trace the presence of syphilis in China as far back as the time of Confucius in the sixth century B.C., and a detailed account of the disease is contained in a ninth-century Japanese medical work.

However, it is interesting to note that none of the many skeletons belonging to all ages and dynasties which have been dug up in Central America (the scene of Columbus landing), and none of the Egyptian skeletons show signs of syphilitic disease of the bones, which almost certainly must have been present if syphilis had been at all prevalent.

The disease must certainly have been present on the islands where Columbus landed, but for how long it had existed there, or whether it had been brought by some other race, we cannot say.

Dry as Dust

To the housewife, dust is just a nuisance which must be got rid of as quickly as possible. To scientists in a great variety of fields of work, very many of them of considerable industrial importance, dusts of various kinds may play an extraordinary variety of roles, from the lethally harmful to the positively beneficent. For example in mines, silica dust is a great source of hazard to the health of the workers, whereas stone dust may be used as a protection against explosion. Obviously then, dusts are more interesting than might have been supposed at first sight, and their possibilities and mode of action are well worth investigation.

Professor H. V. A. Briscoe, in his Cantor Lectures published in the *Journal* of the Royal Society of Arts, has given a truly fascinating account of an investigation into the action of dusts in a field of obvious practical importance, namely the killing of weevils infesting stocks of stored wheat. A feature which makes this investigation particularly instructive is the way in which the researches led almost immediately to the need for fundamental investigations of such matters as the size of dust particles, their chemical and physical nature, and their action on biological tissues, all of which are problems whose answers will eventually lead to fuller knowledge of the action of dusts under quite different circumstances.

The particular problem in hand arose from the fact, established by observation, that dusting the infected grain produced a much higher death rate among the weevils, but the problem became really interesting when Professor Briscoe and his colleagues began to try to discover how the dusts acted: were the weevils poisoned by solutions of the dust?; or was the action mechanical, producing, for example, laceration of the tissues or interference with respiration?; or were the effects due to an action of some other kind?

The obvious line of attack was to try dusts of different sizes and modes of production and of different chemical constitution. Some 250 dusts were tried including Neosyl, a commercial form of pure precipitated silica which is a fairly effective insecticide. Samples were tried which had been extracted with boiling water, or with alcohol and ether or with benzene or other re-agents, but none of these treatments made any significant difference, so that it was evident that the chemical properties of the dust were not particularly significant. The scientists then tried the most inert dust which they could think of, namely fine diamond dust which had been thoroughly cleaned with various chemicals. "Much to our surprise," says Professor Briscoe, "this proved to be far more effective in killing weevils than any of the dusts we had previously tried, and further experiments soon showed that other hard, chemically inert substances like carborundum were nearly as effective."

In a further effort to light on the true explanation they dissected weevils under the microscope to see whether the dusts, such as the diamond dust, or other effective dusts more easily visible, had got into the respiratory systems of the insects, but here again they drew a blank. After an enormous amount of work it began to be clear that two effects were involved: humidity, and the hardness of the dust material used. Weevils flourish in damp atmospheres, which is why grain stored in damp warehouses and holds is most readily attacked, and dusting somehow increases the water loss from the insects, for their corpses are found to be shrivelled and desiccated. However, this effect is definitely *not* produced by absorption of water by the dusts, for some of them, including the most effective, such as diamond, are quite incapable of acting in this way.

It was also found that the harder the dust material the more effective it was, but again, obvious explanations were found not to be correct. A weevil's shell is fairly hard (about 3·5) but dust materials of hardness 3·0 already begin to be effective and increase in effectiveness smoothly up to hardness 10. It is clear then that it cannot be a case of mechanical damage since a crystal of calcite (hardness 3·0) can be scratched on the insect's shell without making any impression, although dusts of this hardness are already beginning to be effective as insecticides.

The practical problem of weevil control therefore seemed soluble by means of a hard finely divided dust most of whose particles were less than one-hundredth of a millimetre in diameter, extending down to one tenth of this. There must be no free silica to create a hazard to the workers who must handle the dust, and the source of material must be cheap, and free from poisonous elements like lead or arsenic. Clinker obtained from establishments such as power stations and then pulverised seemed to be the ideal solution. What was the consternation of the research workers to find that dust prepared in this way was almost completely ineffective. Further investigation revealed however that the clinker had been ground dry, whereas the other dusts had been wetted with ether for convenience in handling. A closer study seemed to show

that the dry grinding might leave the dust particles with an amorphous surface layer, whereas the wet grinding produced angular particles in which the crystalline character of the surface was preserved. That this difference may be of importance is supported by the observation that some ineffective dusts, including even amorphous ones such as glass, can be made effective by etching the surface of the dust, whereas if it is heated so as to produce rounded particles it is quite ineffective.

As a result of these and other investigations it has been found that suitably prepared non-poisonous dusts are effective against many kinds of pests, including Rice weevils, Flour Beetles, Flour Moths, Grain Moths, Grain Beetles and Bed Bugs. The exact mechanism of destruction still awaits explanation. What became clear was that these special dusts promoted loss of water from the insects, indeed at a rate equal to the loss of water from dead specimens. It seems possible, that in some way, not yet explained, the dusts act on the superficial fatty film on the outside of the horny casing of the insects, which may normally be responsible for preventing water permeating outwards, and so kill the insect by upsetting its moisture balance. Experiments are proceeding in an effort to imitate this state of affairs with artificial membranes.

There can have been few investigations to equal this one in the fascinating variety of possible applications, and few which involve so great a variety of techniques and specialities. Professor Briscoe is to be congratulated on having given us a ringside seat, and though its outcome is a foregone conclusion, the contest itself is certain to be worth watching.

Disputed Territory

UNCOUNTED novelists have put their heroines into fixes, and sometimes even got them out again, by the aid of mysterious and improbable "rays", whose secret remains forever hidden. Few people realise however that such unsolved mysteries have on occasion invaded even the prosaic atmosphere of university laboratories, and have remained mysterious in spite of detailed publication of observations and careful checking of facts.

Recently Professor Gurwitsch of Leningrad published a paper dealing with the so-called mitogenetic rays discovered by him twenty years ago. His fundamental experiments were made on rapidly growing onion roots, in which he found that if two growing roots were brought near to each other, and one of them then sectioned and stained, the section showed an increase in the number of cell divisions on the side nearer to the other root. He also found that the effect was stopped if a sheet of glass were interposed, but it was not stopped by a plate of quartz.

From these and other experiments he concluded that the biological process of cell division must be accompanied by a mitogenetic radiation which can stimulate cell division in the tissues on which it falls. His own view was that he was dealing with ultra-violet radiation of a wavelength between 1900 and 2500 angstroms, i.e. well within the range used in routine spectroscopy.

The importance of such a discovery, if well-founded, was obviously immense. It might throw new light on the process of cell division, and might even revolutionise scientific views of the nature of living matter. It might explain the rapid organised growth of embryonic tissues, as well as the unorganised growth of cancerous tissue. That was twenty years ago, and to-day we are no nearer the solution of the puzzle. All over the world biologists, physiologists, medical scientists and physicists have tried to repeat and vary Gurwitsch's experiments, and one would have thought that either his claims would speedily have been proved wrong, or they would have formed the basis of a new and rapidly advancing science.

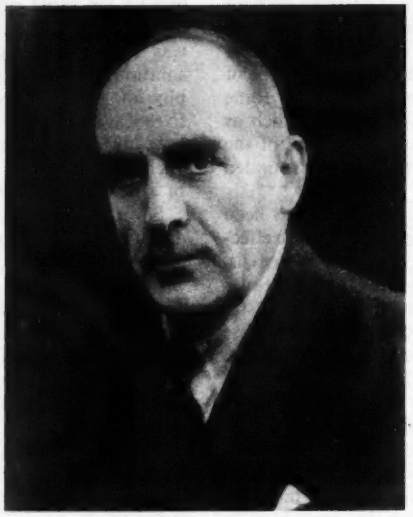
Several books have been written on it; upwards of 700 scientific papers have been published and large scale surveys have been carried out in the laboratories of the Siemens concern in Germany and by the National Research Council of America. Many of the investigators are emphatic in their disbelief of the existence of the radiation, since they were unable to obtain a single positive result. Others no less emphatically take the opposite view, and some have even based methods of estimating fatigue among factory workers on the radiation, claiming that the mitogenetic radiation from blood ceased after exertion.

In between the definitely positive and definitely negative schools of thought are many who have found phenomena believed to prove the existence of the radiation, but endowing it with properties quite different from those observed by Gurwitsch. Reiter and Gabor working at the Siemens laboratories confirmed the original experiments with onion roots but thought that they were due to a radiation of wavelength 3400 angstroms, i.e. to light of a wavelength only slightly shorter than the bluest visible light. On the other hand similar radiation produced from physical sources did not show the effects, a phenomenon which was accounted for on the assumption that the rays from physical sources contained wavelengths additional to those coming from biological sources which inhibited the mitogenetic effects.

Other sources of radiation besides onion roots have been suggested among them blood and carcinomatous tissue. As against this it has been claimed that the blood of carcinoma patients does not radiate, a fact which it has been claimed affords an earlier diagnosis than is possible by any other means.

The difficulty has always been, of course, the detection of the rays, which even if they exist must be very weak. Cultures of yeast and bacteria have been employed as biological detectors, and extensive experiments have been made in the attempt to detect the rays by physical means. There are a few claims of detection by their action on a photographic plate, but even more numerous reports of negative results. The latter do not necessarily disprove the existence of the rays since they may be too weak to be registered even by long exposures. The photocell and the Geiger counter, and combinations of both have been used, again with conflicting results. One of the chief difficulties in the use of Geiger counters is that they are affected by cosmic radiation which cannot be excluded, the statistical variations in whose intensity cannot be separated with certainty from the possible effects of mitogenetic rays.

These are a few of many practical difficulties, but there are theoretical ones as well. If the radiation arises from cell division it will not produce a biological effect simply related to its intensity, for as the incident radiation produces increased cell division this in its turn will produce new sources of radiation, and so on. *[Continued on page 22*



Sir Harold Spencer Jones, F.R.S.

THE ASTRONOMER ROYAL

WITHIN a few years Greenwich Observatory will have become a museum piece. Many people will continue to visit it so that they can enjoy the experience of pacing along the meridian line that has been the world's accepted zero of longitude for the last sixty years; others will want to gaze at the curious old instruments with which Flamsteed, the first Astronomer Royal, and his successors used to study the stars. But the exodus of the scientists from Greenwich Park is inevitable, and the Admiralty, which controls the observatory, has already decided that it must be moved out of London, beyond the sphere of interference of city smoke and the glare of mercury-vapour lamps. It seems most likely that this evacuation will take place during the term of office of the present Astronomer Royal. In the establishment of the new observatory, the great organising ability and experience of Sir Harold Spencer Jones will find abundant scope.

Spencer Jones, who has been Astronomer Royal since 1933, was born in Kensington in March 1890. His father was an accountant who divided his spare time between the study of mathematics and book-collecting. The boy was educated at Latymer Upper School, Hammersmith, which has long enjoyed a high reputation for the standard of its science teaching. An early interest in the stars is not the first or most important qualification that modern astronomy requires of its devotees; what is more essential is that the would-be astronomer shall have a mathematical talent of no mean order. Though Spencer Jones found his liking for astronomy while he was still at school, his success in mathematical studies is of more significance in considering his choice of astronomy as a career.

From school he went to Cambridge as a scholar of Jesus College. Studying under such famous teachers as Welsh, Bromwich, Grace and Larmor, he gained first-class honours on both parts of the mathematical tripos, as well as in Part II of the natural science tripos (for the latter he took physics under J. J. Thomson, C. T. R. Wilson, Searle and Thirkill). While at Cambridge he gained the coveted Smith's Prize. He was also awarded the Isaac Newton Studentship for research in astronomy and physical optics, and a fellowship of his college. In 1913 he was selected by Dyson, then the Astronomer Royal, to fill the vacancy in the post of Chief Assistant at Greenwich.

During his ten years as Chief Assistant, Spencer Jones took a full share in all the varied branches of the work of the observatory, giving special attention to the problems of the variation of latitude, stellar photometry, the measurement of star distances, and the construction of magnetic charts for the Admiralty.

It was during this period that attention began to be given to the need to move certain observational work from Greenwich. Greenwich is responsible for both magnetic and astronomical observations, and early in the 1920's the value of the former promised to be seriously threatened by the proposed electrification of the suburban railway system of the Southern Railway. A number of years before, the introduction of electric trams had presented some difficulties, but the observatory had been able to safeguard its magnetic work by taking full advantage of the protection afforded by Act of Parliament, and insisting that all trams running within three miles of the observatory should have an insulated return circuit; readers will doubtless have noticed that the tramways of the neigh neighbourhood are equipped either with centre rails or with a double

overhead wire for that purpose. When the electrification of the Southern Railway was planned, it became evident that it would be almost impossible to shield the magnetic instruments from electrical interference, and it was therefore agreed that it would be best to move the magnetic work out of London. The Southern Railway undertook to defray the cost of the removal. A site on the slopes of Leith Hill was chosen, and Spencer Jones, who had just been appointed His Majesty's Astronomer at the Cape, spent his last evening before sailing to South Africa in checking over the designs of the instruments intended for the new magnetic station.

At the age of thirty-three, he became director of the best-equipped observatory in the Southern Hemisphere, a post with splendid opportunities, for relatively little knowledge then existed about the stars of the southern skies. A large programme of work planned by Spencer Jones was started in 1926, and the Cape Observatory has now already completed the determination of the distances of more than 1200 stars. The programme also included the measurement of the proper-motions of southern stars, and the determination of star positions by photographic methods using a wide-angle lens camera.

In 1925 a bright nova appeared in the southern constellation of Pictor, and the very fine and complete series of observations made at the Cape Observatory greatly advanced our knowledge of the complex phenomena accompanying the outburst of a new star.

While director of the Royal Observatory at the Cape, Spencer Jones became associated with one of the greatest international adventures that astronomers have ever organised—an endeavour which ended with an estimate of the sun's distance from the earth that is ten times more accurate than any previous assessment. This distance is the astronomical unit in terms of which the distances of the myriads of celestial objects are measured. A model of the solar system can be constructed to scale giving the relative positions of the sun and planets; the scale of the model is determined once any single dimension within the solar system has been measured with accuracy. It was known that the minor planet Eros would be approaching the earth in 1931, and all astronomers agreed that this event would offer an exceptionally favourable opportunity for accurately measuring one dimension of the solar system—the distance of Eros from the earth's centre. Measuring astronomical distances is similar in principle to land-surveying by triangulation, and the longer the base line the more accurate will be the survey. There are two possible kinds of base line that may be used in the triangulation of a planet. Simultaneous observations can be taken at two different observatories, when the base line is the distance between the observatories; or the planet can be observed first in the evening and again in the early morning, when the movement of the observatory itself during the intervening hours (due, of course, to the rotation of the earth on its axis) provides a convenient base line, after allowing for the motions of the earth and of the planet in space. The Solar Parallax Commission, which was set up with Spencer Jones as its president at the Leyden meeting of the International Astronomical Union in 1928, planned the forthcoming observations of Eros on a world-wide basis so that both methods could be employed.

Twenty-five observatories, situated in England, Belgium, Germany, Italy, Spain, Czechoslovakia, Russia, India, China, Japan, Algeria, South Africa, the United States, Argentina and Australia, were brought into the project. Considerable preparations had to be made to ensure that the thirty telescopes to take part could be trained on a sector of sky through which Eros would pass. The first telescope swung into position on October 2, 1930, and the plotting of the path of Eros went on steadily until May 7, 1931; as the planet passed out of the range of one observatory so another took up the trail. (One of the observatories, that of Zo-Se in China, came under shell-fire from Japanese guns during the period, yet the Jesuit astronomers carried on, and from their records came "a good determination of solar parallax.") Spencer Jones, who was at Cape Town for the observations, had the satisfaction of seeing clear cloudless nights throughout the crucial months, a stroke of luck which enabled his observatory to obtain photographs on every single night during January, February and March, 1931. (It may be noted that it was the two photographic telescopes of the Cape Observatory which made the two greatest individual contributions to the observational material; the plates obtained there had more weight than those from all the other observatories put together.)

These observations took seven months, but it was ten years in all before the work of co-ordinating the results, checking and cross-checking, and deriving from them the sun's distance was complete; another important outcome of the project was the most accurate determination of the mass of the moon yet made. The final computations were the responsibility of Spencer Jones. The non-mathematician may gain some idea of the labour involved by perusing Spencer Jones's long and comprehensive description of the whole project and his conclusions which appeared in the *Memoirs of the Royal Astronomical Society* (1941, **66**, Part II). The new determination which, as *Nature* says, "is likely to stand without revision for many years" gives the distance of the sun from the earth as 93,005,000 miles with an uncertainty either way not exceeding 9000 miles; the probable error in the sun's parallax (which is an angle of 8″.790) "corresponds to the apparent breadth of a human hair at 10 miles or of a half-penny at 3250 miles." For his determination of the solar parallax and of other astronomical constants Spencer Jones was recently awarded the Royal Medal of the Royal Society, and the Royal Astronomical Society (of which he was president in the years 1937-39) has also honoured him for this work.

Another field in which Spencer Jones is recognised as the chief British authority is the measurement of time. He has given much thought in recent years to the improvement in accuracy in the time service provided by the Royal Observatory. He has been responsible for the introduction of quartz crystal clocks as precision standards, enabling an accuracy undreamt of ten years ago to be attained.

During this year the Astronomer Royal has visited Spain and Portugal on a cultural mission he undertook on behalf of the British Council. For the same body he has written an excellent "potted" history of the Royal Observatory, which is published in the "Science in Britain" series.

WILLIAM E. DICK

The Night Sky in February

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—Full moon occurs on February 9d. 05h. 29m. U.T., and new moon on February 24d. 01h. 59m. The following conjunctions take place:

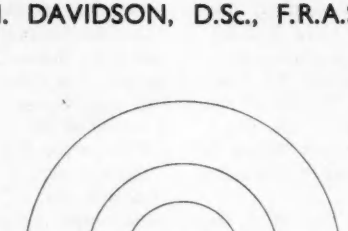
Feb.				
3d.	06h.	Mars in conjunction with the moon,	Mars	7° N.
4d.	07h.	Saturn ,,	Saturn	3 N.
9d.	11h.	Jupiter ,,	Jupiter	0·4 S.
21d.	20h.	Venus ,,	Venus	1 S.
22d.	20h.	Mercury ,,	Mercury	1 S.

Occultations.—The following occultations of stars brighter than magnitude 6 take place, the times referring to Greenwich:

				a	*b*
Feb.	4d. 22h. 58·6m.				
		57 Ori	D	−1·4m.	+0·3m.
	5d. 03h. 23·6m.				
		64 Ori	D	−0·1m.	−1·0m.
	7d. 18h. 36·7m.				
		d^1 Canc	D	−0·7m.	+0·4m.
	7d. 23h. 43·0m.				
		θ Canc	D	−1·5m.	−1·5m.
	17d. 06h. 01·1m.				
		η Libr	R	−1·8m.	+0·1m.

(D and R mean disappearance and reappearance respectively).

The Planets.—Mercury is fairly close to the sun and is not very well placed for observation. It rises at 6h. 28m. at the beginning of the month and at 6h. 44m. at the end of the month, setting early in the afternoon. Venus can be seen in the morning hours, rising a little before 6h. throughout the month. Mars, in the constellation of Taurus, can be easily recognised by its ruddy hue; it is easily distinguished from Aldebaran, the brightest star in Taurus, by its greater brilliance. It is due south at the beginning, middle and



end of the month at 19h. 39m., 19h. 04m., and 18h. 30m. and sets on the same dates at 3h. 57m., 3h. 26m., and 2h. 56m. On Feb. 1 the planet is 83 million miles from the earth and on Feb. 29 the distance is 108 million miles. Jupiter, in the constellation of Leo, is in opposition to the sun on Feb. 11, the sun, earth and Jupiter being then in line. It rises at 17h. 47m. and 15h. 32m. at the beginning and end of the month and sets on the corresponding dates at 8h. 21m. and 6h. 20m. Jupiter is 408 million miles from the earth on Feb. 1 and 410 million miles on Feb. 29. Saturn, in the constellation of Taurus, is a little east of Mars and is fairly close to the 3rd magnitude star ζ Tauri. The planet can be easily recognised by its leaden hue. It sets 15 minutes later than Mars in the middle of the month, the times of setting at the beginning and end being 4h. 35m. and 2h. 42m. Its distance from the earth on Feb. 1 is nearly 780 million miles and at the end of the month it is 818 million miles. Saturn is stationary on Feb. 20.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

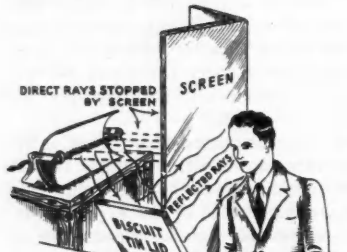
Feb.	Sunrise	Sunset
1	7h. 40m.	16h. 47m.
14	7h. 19m.	17h. 11m.
29	6h. 48m.	17h. 38m.
Feb.	**Moonrise**	**Moonset**
1	11h. 14m.	00h. 33m.
14	22h. 45m.	9h. 33m.
29	9h. 42m.	

The diagram shows the relative positions of the earth, Mars, Jupiter, and Saturn, at the beginning and end of February. The plane of the paper represents the ecliptic. It is impossible to show the small movements of Jupiter and Saturn during the month on this scale, but the different positions of Mars and the earth are shown. The dot in the centre represents the sun.

The constellation of Leo—one part of which is shaped like a sicle—is easily recognised and has a number of interesting double stars. Perhaps the most interesting of these is γ, magnitude 2, which has a companion of magnitude of 3·5. The contrast is well seen with a small telescope, γ being a golden-yellow and its companion a greenish-red. Another double star is ι, magnitude 4, the bluish companion of which, magnitude 7, is 2″·8 away and is visible in a small telescope. Regulus, or α Leonis, is included amongst the fainter of the first magnitude stars, and has an attendant distant 3′, mag. 8.5.

JUNIOR SCIENCE

How does a fire heat the room?



THE answer is: by "infra-red" radiation. The infra-red rays, although akin to visible light, have quite different properties. We cannot see them but our skin registers their presence by a sensation of warmth. It is not the visible red glow of the fire that warms you but the invisible infra-red rays accompanying it.

When you sit in front of the fire you can feel the infra-red rays warming your face and you can tell, even with closed eyes, when a screen is placed between you and the fire. Now hold before your face a pane of glass. It does not stop the visible rays (you can still *see* the fire) but it will stop the infra-red rays and the feeling of warmth in your face disappears. Next put a cheese cloth, half of which has been soaked in water, in front of the fire and move your face behind it from the dry to the wet portion of the cloth. You will find that, while the infra-red rays pass through the dry part, they are stopped by the wet part. The rays are taken up by the water which is heated and rapidly evaporates. You can see the steam rising. That's why things dry so well by the fire. A wet cloth which is partly shielded from the fire by a pane of glass will not dry in the "infra-red shadow" of the glass. Infra-red rays can be reflected like light (see Fig.). Use a *well-polished* metal plate, e.g. the lid of a large biscuit tin. Observe that a looking-glass will not reflect infra-red rays. Why not? (Answer on p. 29).

Carry out these experiments in a scientific manner: John has his eyes bandaged. Peter throws the rays on John's face without telling him when he does it, and John says whether he feels the warmth or not. Peggy takes down a description of Peter's experiments and John's answers. Then John, Peggy and Peter change places and after repeating the experiments, compare results. K. M.

Railway Research

T. M. HERBERT, M.A., M.I.Mech.E.

A RAILWAY differs from most other types of industrial organisations, not only because it is spread over a large area instead of being concentrated in a factory, but because it consists of a group of departments—some technical and others commercial, but all co-ordinated with the primary business of providing transport. Thus, the engineering departments—civil, mechanical or electrical—are, in effect, units of the engineering industry as a whole in that they are manufacturing departments, but they also have to live with and maintain their products in a way that does not fall to the ordinary manufacturer. The commercial and operating departments have to provide the facilities and services required by the public, making use of the products of the engineering departments in so doing. These departments thus play a large part in laying down the requirements which the engineers have to meet. To sum up, therefore, the railways, in this country at any rate, are manufacturers and also users of engineering products, and their research activities have to extend to both functions.

Until recently, very few railways have possessed separate research departments in which all their research activities have been concentrated, and each department has undertaken its own investigational and development work to a greater or less extent. In the early days, too, research was regarded mainly as a matter for the chemical laboratory, and it is interesting to note that the first railway laboratory, at Crewe, was opened as long ago as 1864. The work of these early railway laboratories was, with some notable exceptions, largely devoted to the routine examination of materials and the control of works' processes. Engineering research, on the railways as in the Engineering Industry generally, was not, until quite recently, regarded as something apart from the everyday concern of engineers and draughtsmen, and the idea of a separate team of research engineers free from routine duties is quite new.

Research on the L.M.S.

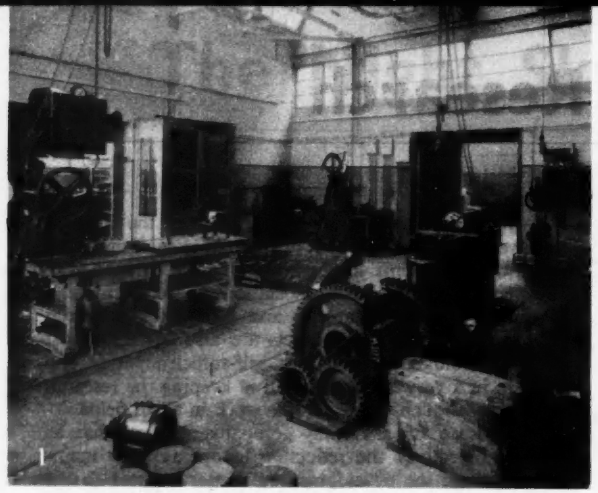
A complete reversal of this policy has taken place on the London Midland and Scottish Railway during the past 15 years, due to the initiative of the late Lord Stamp, who in 1930 appointed an Advisory Committee on Scientific Research consisting of the Chief Technical Officers of the Company, together with a group of distinguished scientists. This Committee sat under the Chairmanship of Sir Harold Hartley, who had lately been appointed a Vice-President of the Company and Director of Scientific Research. This advisory body, after surveying the potential field for scientific research into the problems of a railway, ultimately recommended the unification and extension of the Company's scientific services under the Director of Research, and in 1933 this new organisation came into being. The existing chemical laboratories were retained, but a few years later a new laboratory was opened in Derby (Fig. 1) containing engineering, metallurgical, paint and textile laboratories, whilst at a later date separate sections dealing with physical and chemical research have been added. This laboratory is adapted to deal with a wide range of problems, but even the facilities now available do not make it possible or even desirable to attempt all problems internally, and the Company is a wide supporter of research associations as well as making use of university laboratories and government research stations. These outside contacts are also of the utmost value in avoiding the sense of self-sufficiency that can grow up in a very large unit, and in keeping the research staff in close touch with scientific work in allied fields.

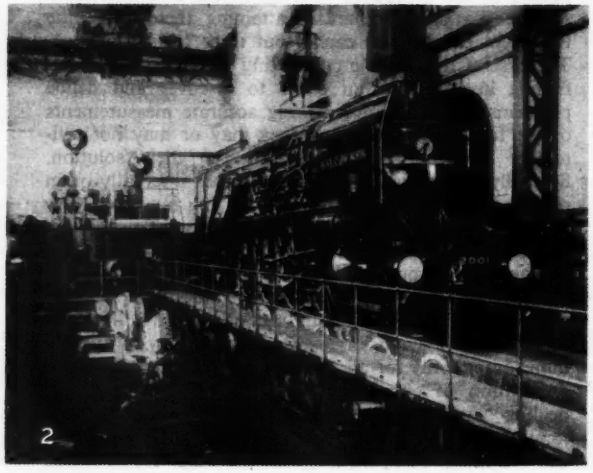
In the case of a railway company, research has as its main objectives the reduction in operating or maintenance costs, the development of better services to the public, or the avoidance of irregularities and failures in service. To play its part in attaining these aims, the Research Department carries out three main functions. The first of these is the conducting of independent fact-finding investigations in order to discover and define problems: these involve making accurate measurements of the factors involved, and they may or may not ultimately lead to further research for their solution. Secondly, the provision of means, either internally or in outside research institutions, for carrying out laboratory or field research when this is necessary. Thirdly, the Research Department tries to keep the other Departments in touch with outside scientific developments and to demonstrate how the scientific method can help in approaching problems both technical and otherwise. A separate research organisation can carry out these duties impartially for all Departments with the minimum duplication of effort, and it is particularly suited to dealing with problems affecting several Departments jointly. It can, of course, only act effectively when it has the fullest co-operation with the other Departments so that they shall not feel that their proper functions or responsibilities are being overridden.

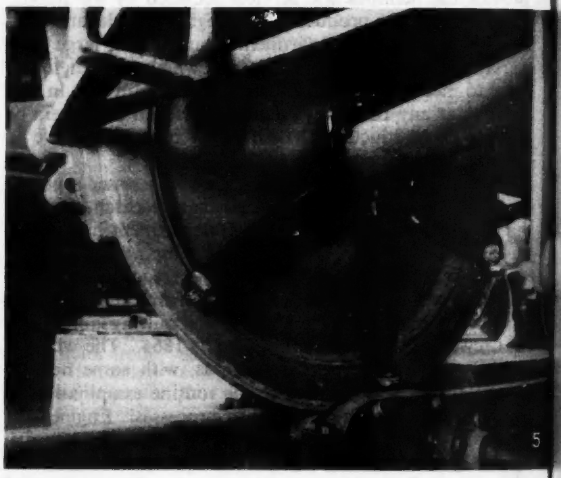
Since the emphasis of this article is to show how an established industry such as a railway can utilise modern scientific methods in solving its problems, it is proposed to consider the various railway activities in turn and indicate a few of the problems arising in each sphere to which scientific study has been given.

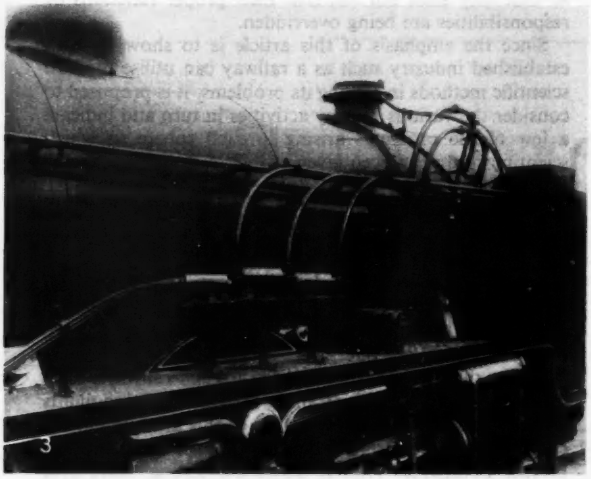
Locomotive Research

The locomotive obviously offers many subjects for scientific study, both from the point of view of its design and also from the standpoint of its operation and maintenance. Research on the complete locomotive is not an easy matter, since tests on the road are subject to uncontrollable variables. Several railways, such as the Great Western, the Pennsylvania and the French railways, have incurred the expense of installing stationary testing plants (Fig. 2), and a modern installation of this kind was in the course of construction before the war for the L.M.S. and L.N.E. Companies jointly. Even the testing station, in which the locomotive remains stationary whilst the wheels rotate on rollers, does not enable every problem to be studied completely, because the behaviour of the locomotive is in many directions dependent upon its actual









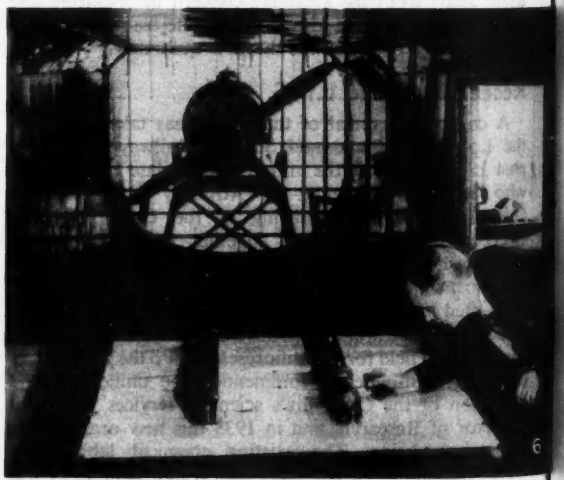


FIG. 1.—A corner of the Engineering Test Room in the L.M.S. Research Laboratory at Derby. 2.—L.N.E.R. locomotive on the stationary testing platform at Vitry, near Paris (*by courtesy of the "Railway Gazette"*). 3.—Apparatus for sampling products of combustion from the locomotive boiler. 4.—Screens for detecting oil splashing. 5.—Apparatus for detecting flaws in carriage axles. 6.—Wind tunnel test on streamlined locomotives.

movement. This affects particularly the questions of stability and of the combustion process in the boiler.

Some years ago a very thorough road investigation was carried out to determine the heat balances of a number of modern locomotive boilers, with the object of finding out just how heat was wasted. Some of the coal passes unburnt up the chimney—as much as 30% in some circumstances: a method was evolved to determine when this loss occurred, and a sample of the products of combustion was passed continuously through a high temperature furnace, and continuous analyses of the gases before and after complete combustion enabled the loss due to unburnt fuel to be computed (Fig. 3). Results of value to subsequent design were obtained, and as an incidental but most valuable result it was shown that if the locomotive was fired at strictly regular intervals the coal consumption could in many cases be reduced by 10%. Even these tests, valuable as they were, would have been more convincing still if they could have been carried out under rigidly controlled conditions of constant speed.

An attempt to overcome these difficulties of road testing was developed by the Research Department and three mobile testing units were constructed just before the war; these units consist of bogie vehicles carrying electrical generators with automatic controls, whereby the load behind the engine can be so varied as to compensate for changes in gradients or external resistance, in order to maintain constant speed. These mobile units are complementary to the stationary testing plant and together they will, after the war, afford very complete means for scientific locomotive testing.

The day-to-day reliability of the steam locomotive is only attained at the cost of constant maintenance and inspection, in order to detect in good time any defects such as unavoidably occur in a machine of this type, which is naturally subjected to heavy wear and tear in service. During the past ten years, a great deal of attention has been given to discovering the causes of the failures of tyres, axles, etc. These failures are brought about by rapid changes in stresses, and as a result of a better understanding of their cause and development, improvements in design and manufacture have been introduced with beneficial results. For example, better machining of the tyres and axles has improved by 20% the resistance of the metal to these fluctuating stresses.

The behaviour of the locomotive when running has given rise to numerous fact-finding investigations, of which the following two are typical examples. Owing to the fact that the reciprocating parts of the steam locomotive, i.e. the pistons and connecting rods, cannot be perfectly balanced, there is an unavoidable variation in the load between the driving wheels and the rails, which, at high speeds, around 100 m.p.h., have been alleged to cause damage to the track and even to cause the wheels to lift from the rails. These allegations were ultimately confirmed in a spectacular manner by means of a controlled experiment, which showed that the locomotive driving wheels could lift 2 or 3 inches off the rail at high speeds (Fig. 7). This was recorded by means of the cine camera, and indicated the optimum extent to which the reciprocating parts should be balanced. The other example relates to an attempt to reduce the oil consumption of the locomotive, in connection with which it had long been expected that an undue proportion of the oil was thrown off the moving parts without doing useful work. The question arose, however, as to just where the oil was thrown off and this was eventually determined by fixing a number of screens at various points along the locomotive so that the oil thrown from likely points would be caught and clearly indicated on the screens, which were then photographed as a permanent record (Fig. 4). These are two examples in which argument was convincingly settled as a result of a properly conceived experiment.

Safety and Comfort of Passengers

Many similar investigations have been carried out on carriages and some of these are the counterpart of problems experienced on the locomotive, for example that of detecting flaws in carriage axles. These flaws unfortunately occur on the wheel seat underneath the hub of the wheel, and they cannot be found without removing the wheels from the axle. As an axle with its wheels in position is difficult to subject to magnetic or electrical methods of detection, the problem was ultimately solved by using a simple deflection method. The coach is placed so that the wheels of the axle under test rest on a set of rollers (Fig. 5). Dial gauges, supported on radial arms rigidly clamped to the axle, indicate the deflection under load of the short length of axle in which the flaws occur. A sound axle will deflect to an equal amount as the assembly is rotated, whereas, if a flaw is present, an abnormal deflection is recorded when the test is made in a plane passing through the centre of gravity of the flaw.

Many research problems connected with rolling stock are concerned with factors that affect the passengers' comfort, that is to say with the smooth riding characteristics of the vehicle, the reduction of noise and dirt and with improved methods of heating and ventilating. As regards smooth riding, an investigation was carried out, partly at Cambridge University and subsequently in service, to determine beyond doubt the causes of bad riding. This is inherently due partly to the intentional coning of the tyres, which causes the wheels to oscillate from side to side, an effect which is accentuated as the tyres wear down from their original profile. As the result of this investigation, a marked improvement was effected when the coning on the tyres was reduced from 1 in 20 to 1 in 100.

The problems of heating and ventilating, which are, to some extent, allied with those of the suppression of noise and dirt, have been given a great deal of attention, and the fact that scientific methods have afforded proper means of measuring the various factors involved is helping greatly in deciding upon the improvements desirable.

Finally, the question of keeping the exterior of carriages clean has provided many difficult problems, both in providing suitable cleaning agents and in developing painting processes which will stand up to their use. Cleaning agents which are strongly acid or alkaline are very effective, but deleterious in action, though just before the war there were good hopes that the newer types of synthetic resin finishes would be more resistant to the action of cleaning agents. These improved paints have also enabled a reduction to be made in the number of coats of paint required; in 1914, 17 coats were quite

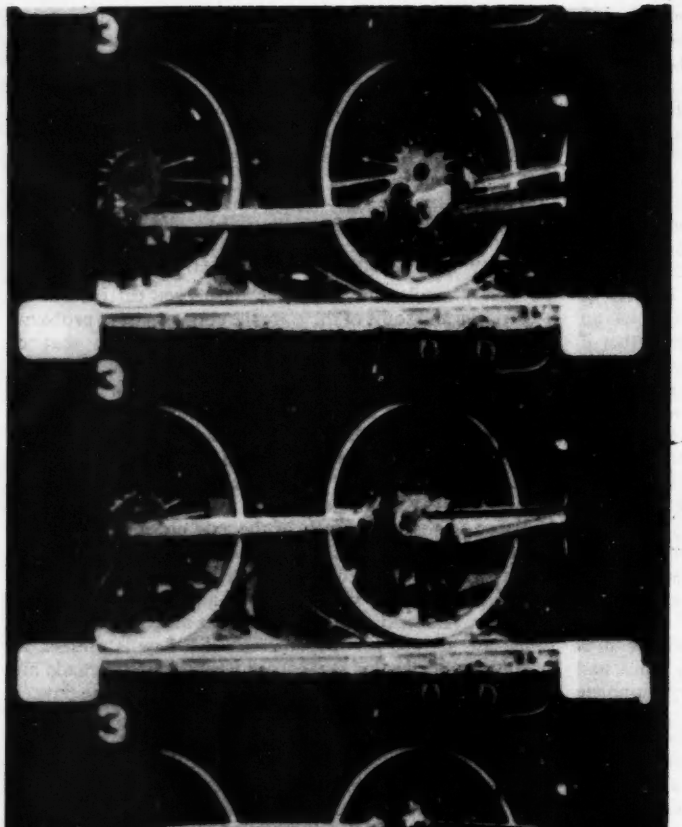


FIG. 7.—Driving wheel lifting at 105 m.p.h.

usual, whereas this number had been reduced to 8 or even 6, just before the war. Incidentally, investigations in regard to paints are a good example of the reason why railways must do their own research rather than rely on the manufacturers, since the latter cannot have a full appreciation of the conditions to be met nor can they watch the progress of experiments from day to day. Furthermore, of course, the railways must have their own means of assessing the behaviour of new developments put forward by the trade.

Track Research

The civil engineering side of the railways is concerned with the permanent way and with structures and buildings. As regards the track, the requirements are that it shall be strong enough to carry traffic at modern loads and speeds with the minimum of maintenance and without giving rise to uncomfortable riding or noise. A comprehensive survey was in hand before the war to measure the stresses in the sleepers, chairs and rails to ascertain whether the high speeds then operative were tending to put up the stresses unduly in one or more component. Again, much work was undertaken on rail joints in order to study the effects of sleeper spacing, length of fishplates, maintenance, etc. Most of this work is field research, and has involved the design and manufacture of special apparatus, which could readily be transported to any desired location. In measuring stresses, the problem has been approached from a rather different angle from that adopted by the association of American Railroads which has for many years been conducting track research on behalf of the railways of the U.S.A. There the primary concern has been the study of rail breakage due to particularly heavy wheel loads, and the oscillograph has been extensively used to detect the influence of individual loads. Here the principal object has been to detect the maximum stresses likely to be met with in service, and great reliance has been placed on the scratch extensometer which has the great advantage of simplicity and which indicates without necessarily identifying maximum stresses.

Similar methods are now being applied to the measurement of stresses in concrete sleepers, both in the concrete and in the steel reinforcement.

Rails suffer from various troubles, some of them due to metallurgical defects, others due to purely wear and tear effects. Prolonged slipping of the wheels can cause surface defects (Fig. 8) due to the formation of martensitic streaks which subsequently exfoliate, and the possibility of overcoming this defect at certain specific situations by the provision of bronze inserts in the rail head is now being studied. In some countries heavy wear at the rail ends is a serious trouble, which is being mitigated by hardening the ends by heating and quenching them *in situ* An investigation has been made to see whether end hardening would improve the condition of the rail joint in this country by maintaining the ends in a square condition.

Amenities

In buildings, as in trains, the question of noise elimination is always a desirable amenity and, in bad situations, a virtual necessity. Apart from suggesting remedies for particularly bad cases and measuring the improvement thereby attained, complete noise surveys have been made

prior to the erection of some important new buildings in order to assess the need or otherwise for special precautions such as double-glazed windows. Just as in the case of noise, vibration often presents difficulties which it is hard to assess or remedy without actual measurements on which to base judgment. The ability to make measurements of this kind is an important function of a research department, and one which the railway exploits sometimes in quite unexpected directions, e.g. in measuring the flow of water into and out of a complicated section of railway-owned canal.

Signalling

As regards signalling, problems are constantly being referred to the Research Department, many of them being concerned with rare and unexplained failures of relatively delicate apparatus, though others have related to the apparently much simpler problem of a signal lamp being extinguished in a high wind. In both types of problem the advantage of bringing the problem into the laboratory, after full enquiry in the field, is that the behaviour of the apparatus can be studied under controlled conditions, altering only one variable at a time, and obtaining permanent records of performance under a known set of circumstances.

In one case a hand-operated block instrument appeared liable to fail if too roughly handled, but the action in any case took place in less than a second and the actual method of failure could therefore not be detected with the eye. Here the high-speed cine camera took a film of this rapid event, and by running the film subsequently in slow motion the difficulty was elucidated immediately. In the case of the lamps, a number of variables enter into the problem; the design of lamp, the state of maintenance, the quality of the burning oil, as well as wind and vibration influences. It was quite impossible to separate these variables in the field, or even by statistical methods. In the laboratory, however—using in this case a wind tunnel for producing the wind effects—the problem is being broken down into its constituents and the various effects studied separately.

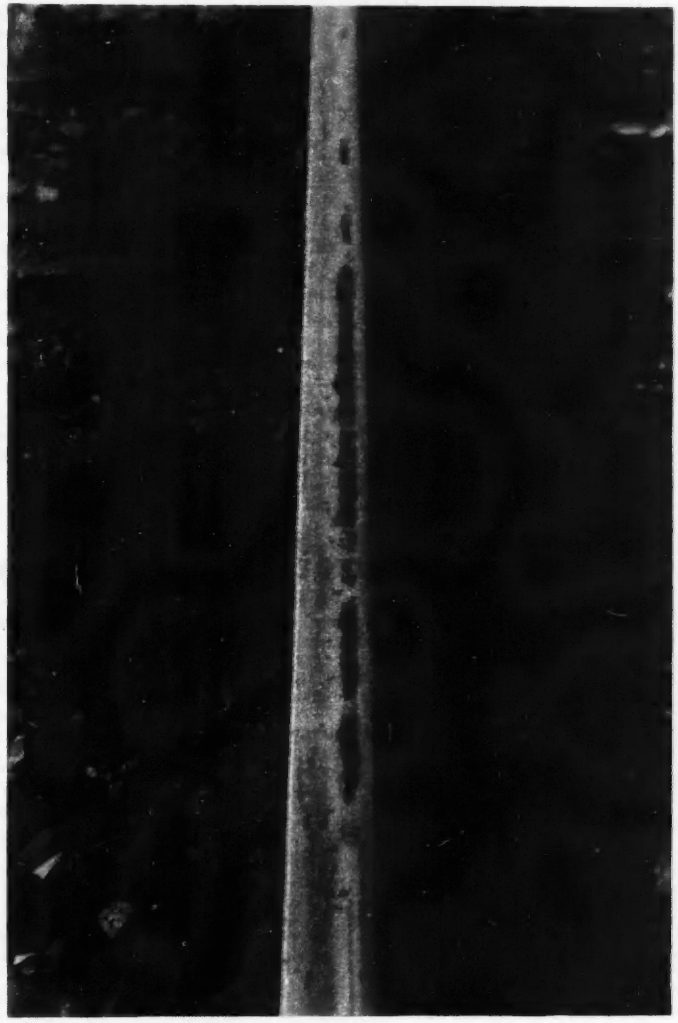


FIG. 8.—Surface of rail damaged by wheel slip.

Refrigeration

All the above examples have concerned the purely technical departments of the Company, but in varying degrees the non-technical departments provide problems for scientific research, or at least for analysis by scientific methods. For example, the Commercial Manager maintains a research section dealing with market and traffic research, but problems are occasionally met with in which a scientific angle is involved, as for example in the case of refrigerated transport. Here, the Research Department has been a link with outside scientific bodies concerned with food preservation and has assisted in working out suitable methods of refrigeration for various classes of perishable goods. It has further supervised the passage of trial loads in order to measure the actual temperatures during the journey. Arising out of this work, attention has been given to developing a small refrigerated van carrying an absorption unit energised by low pressure steam from the steam heating supply on the train. Such an arrangement has the advantage of having no moving parts, but the scope for such vehicles in this country is limited owing to the short journey times, and it remains

to be seen whether post-war requirements will necessitate further development.

The Weather

As in the case of the Commercial Department, actual railway operation provides a variety of scientific problems some of them of a meteorological character. The worst enemy of the railway is probably fog, and whilst the ultimate goal would be effective means of dispersing it, at any rate at critical points, considerable benefit would accrue if accurate forecasts of fog could be made available. Some experiments in fog dispersal were started prior to the war, but this hardly seems likely to be a promising line, but there is probably more hope in regard to the organisation of fog warnings, numerous trials having been carried out in collaboration with the Meteorological Office.

Frost, too, can be a hindrance to railway operation, particularly where there are water troughs from which engines pick up water whilst running, and quite recently the Research Department has been studying the problem of preventing these troughs from freezing, though the results of the analysis indicate that the cost might be high. Again, high winds can interfere with railway operation. The streamlining of locomotives and trains to reduce wind resistance saves coal at high speeds, but relatively few trains are affected and the streamlined locomotive suffers from lack of accessibility to the moving parts. Nevertheless, a very complete study of this problem has been made, partly at the National Physical Laboratory and partly in the L.M.S. wind tunnel at Derby, where the outward form of the "Coronation Scot" locomotive was determined (Fig. 6). Strong side winds can also interfere with operations in marshalling yards, where they slow down the normal running of wagons. At one large yard, this problem has been examined and a marked improvement effected by the erection of windscreens.

In all these examples, it has been the intention to show broadly the type of problem which is being tackled by scientific methods up and down the line so as not to give the impression that railway research is necessarily confined to the chemist at his bench in the laboratory. This type of work, of course, also exists and is in many cases ancillary to the field investigations of which the above examples are typical.

The Education Bill: ability and aptitude

THERE are many aspects of the new Education Bill which should prove of interest to readers of this journal, since it relates the education service in a new way to the gradual selection of skill, the encouragement of citizenship and the development of a more cultured community. It also marks a new attitude to the social services and a new conception of the functions of government, local and central.

In addition to the compromise with regard to religious education and the position of non-provided (now to be called "auxiliary") schools, there is an indication in the new duties of the parent and of the local authority of a greater emphasis upon personal and community factors than hitherto.

The parent must now cause his child "to receive efficient full-time education suitable to his age, ability and aptitude," while the local authority has the duty "to contribute towards the moral, mental and physical development of the community." This is a revolution, and it is not surprising that the Education Act of 1921 is completely revised, that the President of the Board is to have the executive powers of a Minister and that, while preserving minor local authorities as "divisional executives", the new powers are concentrated in the councils of counties and county boroughs. The new programme demands a new organisation and will call for the best ability which can be found.

The former division into elementary and higher education ceases, and there are to be three successive stages. Junior children under 12 will attend primary schools; senior children will attend secondary schools from 12 to 15 (from April, 1945, if possible) and later to 16; while the third stage, known as further education, will comprise young people's colleges, technical, art and commercial courses, and the various aspects of adult culture. For each of these three stages, authorities will be required to devise a development plan.

Primary and Secondary Education

In the primary stage the chief needs will be for more teachers and improved buildings. In the secondary stage the main problem will be to secure opportunity for all children to take full advantage of the varied courses in grammar, technical, and modern schools. In appropriate cases there will be boarding accommodation. In all maintained schools education will be free and necessary expenses may be met by the authority. Fees may be paid in respect of children attending schools at which fees are payable.

Independent or private schools are to be registered and must have suitable premises, suitable staff and curricula, to the satisfaction of the Minister.

In association with a proposed comprehensive health service the Bill provides for free medical treatment for pupils attending any maintained school or young people's college. Milk and meals must be provided and authorities may provide clothing. Special educational treatment including special schools, is to be available for children suffering from any disability of mind or body.

Employment of any school child may be prohibited or conditioned if considered prejudicial to his health or education.

Further Education

The plans for the further stage of education are to develop all forms of vocational and recreational education and to include facilities afforded by voluntary bodies. They will include young people's colleges for persons between the compulsory leaving age and 18 who must attend for the equivalent of 44 weeks in the year.

At all stages of education authorities may establish or assist many kinds of provision for recreation and social life. This will enable a wider view to be taken of adult education. In further education there is to be a more generous provision of scholarships which will enable ability to be encouraged without undue emphasis upon competition.

New Opportunities

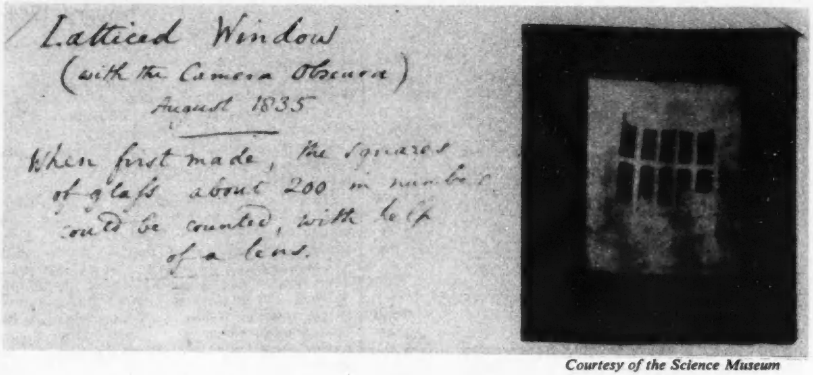
It will be seen that a greater opportunity is offered to children of ability. Such boys and girls reaching the age of eleven will be placed in an appropriate type of secondary school and will not only lay the foundation of future studies but will receive careful guidance derived from a careful review of their skills and interests. It is important, however, that the emphasis on equality of opportunity must not lead to a lowering of the best standards of secondary education. Freedom from fees and more adequate assistance should ensure that the poorest child will receive full benefit from the varied secondary courses. This should mean less educational waste, especially in the spheres of university and technical courses.

The new powers to aid bodies not directly associated with the maintained education service will develop adult activities, enabling interests and aptitudes to be encouraged.

These measures should go far towards enabling the full development of abilities to the advantage of the individual and the community so that native skill may be fully used and a better citizenship may arise.

The speedy passage of the Bill through Parliament and the implementing of the Act demand the support of all who desire the best education possible for the people of this country.

E. W. WOODHEAD



Courtesy of the Science Museum

FIG. 1—Original size (above) and enlarged copy (below) of the earliest miniature photograph in existence, taken by Fox Talbot in 1835.

Microphotography: 1835—1870—1944

LUCIA MOHOLY, A.R.P.S.

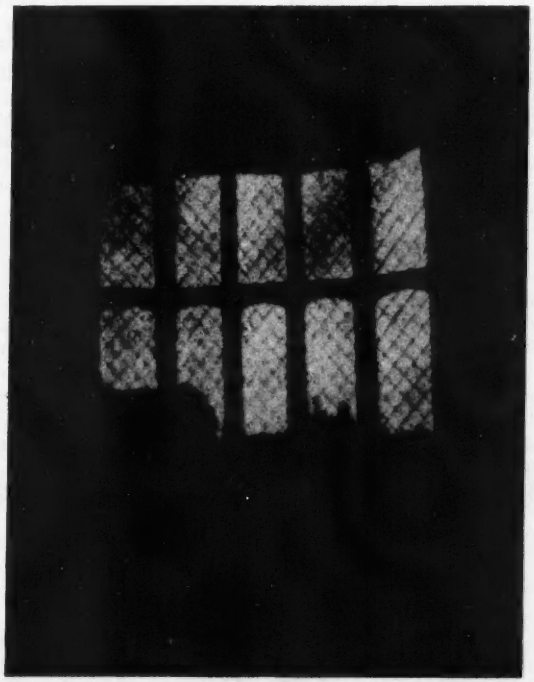
THOSE amongst us who use microfilms extensively, feel that tribute is due not only to recent research and enterprise, which have provided us with modern equipment and material, but equally to the early discoverers who pointed in the direction of our present activities some considerable time ago. Without wishing to minimise recent developments, it is felt that attention should in fairness be drawn to Fox Talbot, who was led by his "photogenic" experiments to foresee and predict the essentials of many later inventions in the photographic field.

Among the photographs taken of his house at Lacock Abbey, "the first building that was ever known to have drawn itself a picture" is a 1 inch square photograph of a latticed window with approximately 200 squares of glass (see Fig. 1). These squares, undistinguishable to the naked eye in the original picture, could—as Talbot's own comment goes—be counted with the help of a lens. Translating this picture and Fox Talbot's comment into modern technique and usage, we have before us the first evidence of microphotography and devices for deciphering miniature photographs.

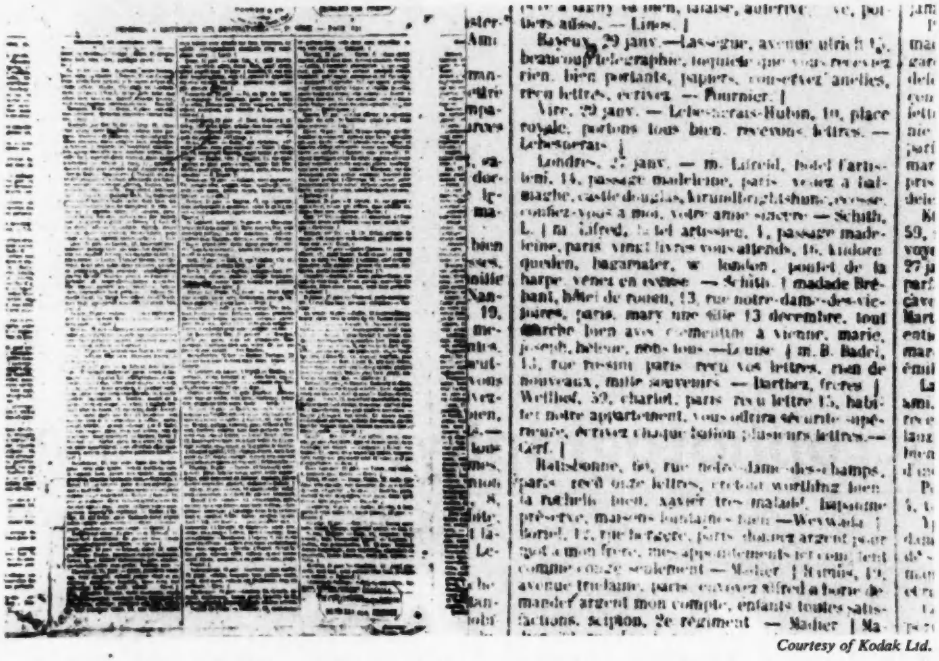
Used in Franco-Prussian War

Microphotography has a very extensive application in many branches of science, especially in biological and mineralogical work. In wartime and for some years before it had begun to be applied to the reproduction of documents on a very small scale, for ease in transport and storage.

It is not without topical interest that the first practical use on an appreciable scale known to us to be made of microphotography was due to war conditions during the Franco-Prussian war of 1870-71 (Fig. 2). Communications between besieged Paris and the outside world were kept up by pigeon-post. In order to make the most of this pigeon-post, Dagron, a Paris photographer, reproduced messages in miniature form on photographic plates. By means of a special method, using collodion and castor oil, the emulsion was pulled off, dried and carefully rolled up, and finally inserted in a quill and carried by the pigeon to its destination. These miniature photographs, approximately 1 square cm. in size, were unreadable with the naked eye and were, for reading purposes, enlarged by means of a system of lamps and lenses, early models of later projectors. The original size of the printed matter photographed by Dagron is not known, but it can be assumed that the size of the sheets was very nearly the average size of a modern newspaper. If this is correct, the ratio of reduction was anything up to 35 diameters or even more.



What Dagron did was in



Courtesy of Kodak Ltd.

FIG. 2.—Microphotograph (then called photomicrograph) of pigeon-post message, 1870.

keeping with the technique and the means of transport some 70 years ago. Progressive technique, improved methods of production and new means of communication are available for similar tasks carried out to-day. The basic idea has remained the same. Millions and millions of airgraph letters keep Great Britain in touch with her Empire and the nation at home with her fighting forces abroad. A letter written on a sheet of approximately 80 inches square is reduced to no more than a quarter-inch square (approximately 1 cm. square) on 16 mm. film. For transport purposes bulk and weight of letters are thus reduced to a fraction of the originals. The advantages are evident. On arrival the film image is enlarged to about a quarter of the size of the original document, making it just readable.

Modern Usage

For transmission of printed matter, a film of 35 mm. width is commonly used (Fig. 4). Reduction varies according to the originals photographed, the type of film, and the requirements of the individual user. Printed matter can be photographed with the lines running parallel to the edges of the film or with the lines at right angles in relation to the edges; one page per exposure or two pages per exposure; one page occupying the whole width of the film or two or four pages respectively sharing the space.

Under the auspices of the British Council some 90-100 British journals, DISCOVERY among them, are now regularly microfilmed for the use of science workers in China, who under present conditions are unable to obtain the originals within a reasonable time. An issue of DISCOVERY, reduced at a ratio of 11 to 12 diameters, covers a strip of film approximately 27 inches long. An annual volume, if photographed jointly or joined later, will occupy 27 feet. These measurements allow for each page to be included once. In fact, however, certain pages require two "shots": a short exposure for text and charts and a longer one for illustrations. Even so, a 100 ft. roll of film will accommodate approximately three annual volumes of this journal and can easily be stored in a cylindrical container 4 inches in diameter and 1¾ inches in height. (Fig. 4.)

By special arrangement six positive copies on microfilm of each journal are sent to a representative of the British Council in China, whence they are distributed to centres in various parts of the country. The master negatives are stored in London, and additional copies can be produced when required. For purposes of quick reference each roll of film is marked with serial letters and each item is numbered consecutively. This allows immediate location of the film and identification of the title and issue wanted.

Illustration 5 shows a microfilm image of DISCOVERY enlarged on paper at 3 different ratios of magnification.

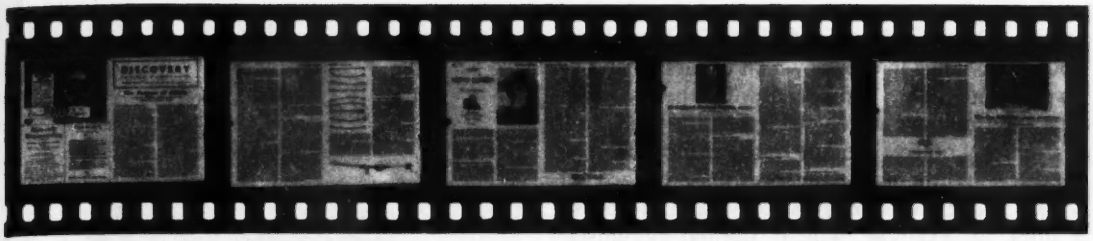


FIG. 3.—Strips of film (at top and bottom of this page) showing pages of DISCOVERY as photographed for use in China.

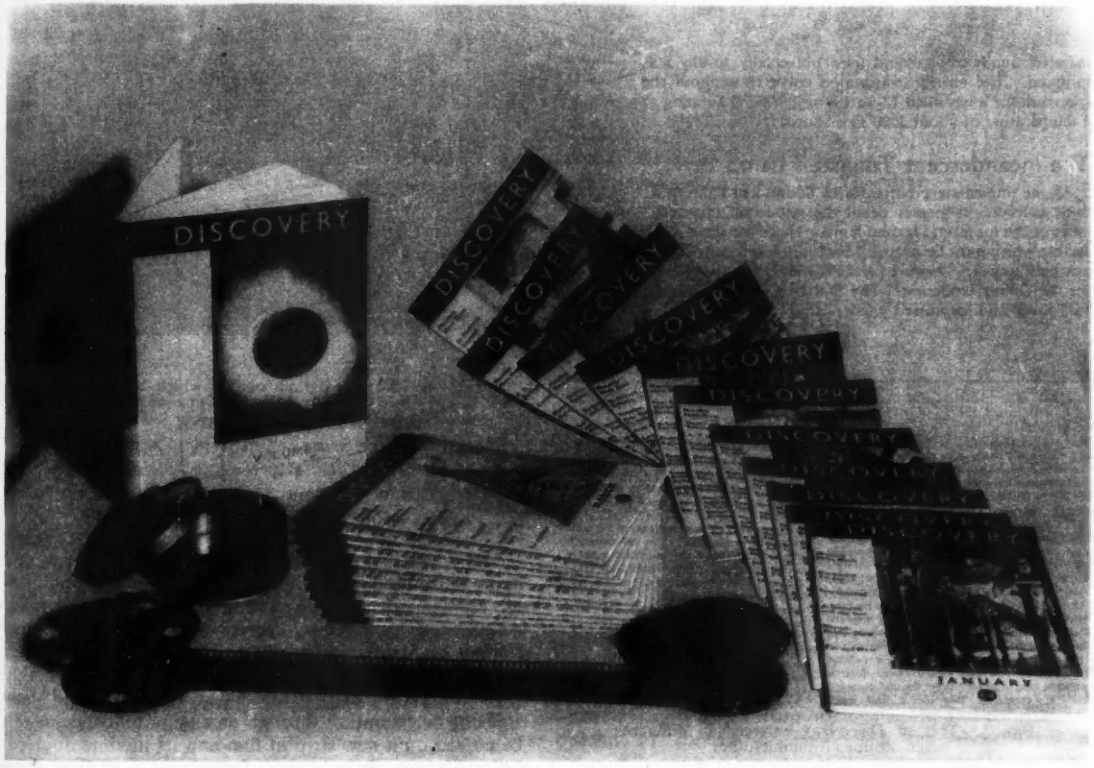
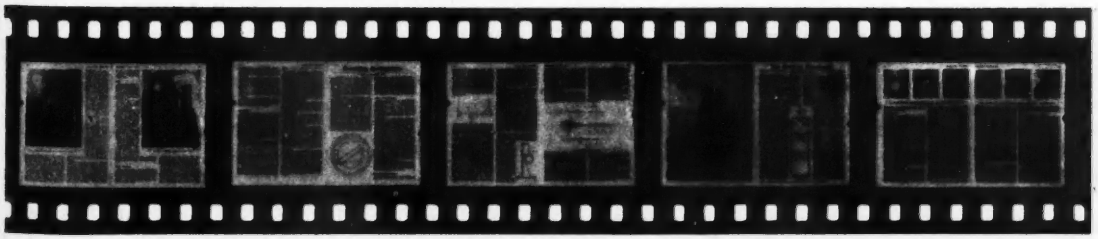


FIG. 4.—Reel of film and container which gives a comparison of the amount of space occupied in sending microfilms equalling three volumes of DISCOVERY.



· term colour rendering requires some fur
nation. By the colour rendering of a lamp is me
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iewed in its light, compared with their colours
ght. The colours which we associate with the
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er ones, for example, will, in normal circumstar
ır red: the actual hue in each case being exa

material finally chosen and used universally to-day was tungsten. The energy distribution curve throughout the spectrum for a gas-filled 75-watt tungsten lamp running at a temperature of about 2500°C is shown in Fig. 2.

The Incandescent Tungsten Lamp

As the immediate predecessor of fluorescent lighting we must consider in greater detail the important characteristics of the tungsten filament lamp. There are three main factors which must be taken into account when considering any light source. They are (*a*) the efficiency, (*b*) the colour, (*c*) the colour rendering. The first two of these can be measured and expressed numerically, but the colour

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gate, at the distal end of the boom is a magnifier;
ns of an oil cup and blade, the boom is coupled to
ng mirror, labelled I in the diagram. A slit light
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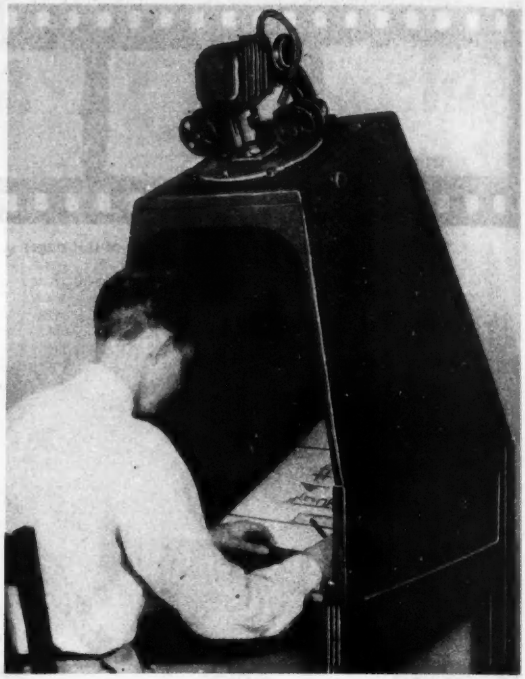
FIG. 5.—Text of DISCOVERY enlarged in different magnifications from microfilm.

This is frequently done for home consumption; it would, however, defeat the main purpose of microfilm, i.e. the reduction of bulk and weight for long distance transport. The reduced image, which cannot be read with the naked eye, is generally magnified by means of screen projectors or desk projectors known as microfilm readers (Fig. 6). Approximately 100 microfilm projectors have been sent to China, and a regular flow of scientific information is also reaching the country from the United States. The film in these microfilm projectors is carried by sprocket wheels; no other but double perforated film may therefore be sent to China. Since a considerable portion of film space is taken up by the two rows of sprocket holes, the reduction ratio must obviously be higher for records on perforated as against unperforated film.



Ansco Micrograph Co.

FIG. 6.—An Anscograph reader, which throws the image from the film on to an opaque screen. It allows magnifications of 14, 22 and 30 diameters

Post-War Value

The space-saving capacity of microfilm has induced many publishing houses to discontinue rag paper editions of newspapers and to introduce microfilm instead. Accelerated ageing tests carried out by the American Bureau of Standards have established that microfilm on acetate base has a lifetime which compares favourably with the lifetime of best rag paper. Should a film show signs of deterioration through damaging influence, it can be copied on a new strip of film and its lifetime doubled. Many libraries, for purposes of preservation or duplication as well as a safeguard against loss by enemy action, fire, etc., are having their most valuable possessions—manuscripts, catalogues, card indexes—microfilmed, and banks and other offices have their business records, cheques, etc., reproduced by the same method as a matter of daily routine.

An overwhelming portion of the microfilm work done in the last few years has been on a purely war-time footing, though some of the war-time services, like the airgraph letter which has become a public institution, will no doubt be carried on into more peaceful times. Beyond this a vast amount of valuable experience has been gained and innumerable possibilities have been opened up for new tasks ready to come forward as soon as the immediate needs of the moment recede into the background.

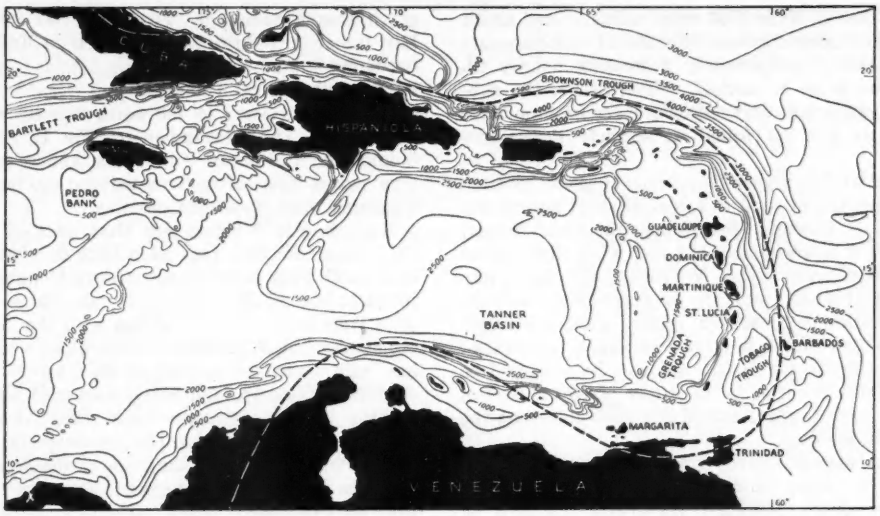


FIG. 1.—Map showing the West Indian arc of negative gravity anomaly (from Daly, after Hess).

The Floor of the Ocean

O. M. B. BULMAN, Sc.D., F.R.S.

OCEANOGRAPHY as a science may be said to take its origin from the great "Challenger" Expedition sent out by the British Government in 1872. During a circumnavigation of the globe lasting three and a half years, the team of scientists on board made continuous observations on depth, temperature and salinity, currents, animal and plant life, and bottom deposits, presenting their results in the classic "Challenger Report" of fifty quarto volumes. Much has been done since by expeditions from nearly every country, yet it is not too much to say that we are still only on the threshold of an adequate knowledge of the great ocean spaces. How great these are is perhaps not always appreciated, but 140 of the 197 million square-miles of the earth's surface are covered by ocean, and of these nearly 120 million lie at a depth of 1000 fathoms or more.

Geology has a deep concern in such investigations, and a considerable part to play. Three-quarters of the stratified or sedimentary rocks (which are the preponderant element in the visible and accessible earth's crust) were marine in origin, and our deductions regarding past marine environments are conditioned by our knowledge of the present. But even more fundamental are questions of the origin and significance of the great ocean basins themselves; and while their origin still baffles us, we are beginning to appreciate something of their significance. "The major mysteries of land geology itself are planetary and to a large extent their secrets lie hidden under the ocean." Professor Daly,[1] from whom we quote, has written in words "not unbearably technical" of certain geological aspects of this subject. In his three chapters he considers the structure and thickness of the earth's crust beneath the ocean, the mountain structures on the sea floor, and the topography of the submerged continental platforms. That is to say, he has selected just those aspects on which the most significant recent advances in knowledge have been made, and his unrivalled gift for popular exposition sustains the reader's interest throughout.

[1] *The Floor of the Ocean* by R. A. Daly. (The Page-Barbour lectures at the University of Virginia, 1941). University of North Carolina Press, 1942. (Oxford University Press, 15*s*. 6*d*.).

Structure of the Earth's Crust

The study and analysis of earthquake shocks and the propagation of different types of shock-waves have revealed that the earth is far from homogeneous, and consists of a series of concentric shells. The outermost layer or "crust", some 40 miles thick, is composed of granitic, intermediate and basaltic layers; they are crystalline in structure and their constitution is inferred in the main from their specific gravity, itself deduced from the variable speeds of transmission of shock-waves. Below the basaltic layer, material believed to approximate in composition to the mineral olivine extends about half-way to the centre, though this again is almost certainly layered; and there is, for example, some evidence for the existence of a sulphide layer at considerable depth. The greatest discontinuity in physical properties occurs about half-way to the centre of the earth, and within this inner sphere the material is incapable of transmitting distortional shock-waves; that is to say, it behaves as would a liquid, and its specific gravity approximates to that of iron. Hence we believe that the nucleus of the earth consists of a

molten iron core of some 2000 miles radius, round which are disposed concentric spheres of material which appears to be solid and of progressively decreasing density till the superficial crust is reached. Nevertheless, the sub-crustal layer can be curiously responsive, and its anomalous behaviour has not yet found an entirely satisfactory explanation.

Professor Daly has argued that it may be glassy basalt—virtually a liquid, but rigid to forces of short period and hence able to transmit distortional or shear waves; others regard it as crystalline, but with a mobility due to recrystallization under stress. Whatever view may eventually be established, mobility is required to account for the depression of continental masses under the weight of polar ice-caps of the last (or Pleistocene) glaciation; and areas such as the Baltic are still recovering (the Gulf of Bothnia is rising to the extent of 10 millimetres annually) as readjustment establishes itself following the melting of the ice-sheet.

Continental masses stand up in average about half-a-mile above sea-level, while the ocean basins average two and a half miles deep. So-called gravimetric methods of investigation—that is to say, exceedingly delicate measurements of the force of gravity at various points on the earth's surface—have shown that the projecting continental masses are composed of lighter rock than the material underlying the sea floors. In other words, the continents can project so much above the average level of the sea floor because they are composed of lighter material; and they are, in a sense, floating on a denser layer rather like gigantic icebergs in sea-water. Thus the granitic and intermediate layers of the crust are not continuous over the earth's surface, but *are* the continents; while the ocean bed is floored by material of the basaltic layer. Further, it has been shown that the difference in density between sub-continental and sub-oceanic rock is confined to a superficial layer some 50 miles thick. What is known as isostatic adjustment of masses of varying density above this level is thus responsible for the stability of those major planetary features which we call continents and ocean basins.

Mountain Chains in the Sea

The most remarkable gravimetric work is the survey planned and carried out within the last 20 years by Dr. Vening Meinesz, of the Netherlands Geodetic Commission, to whom belongs the credit of a fantastic submarine exploration. Meinesz designed a special pendulum for use in a submarine, which, submerged to a depth of 200 or 300 feet, eliminated the effect of wave-action; and with this he obtained numerous measurements of gravity over the Atlantic and Pacific Ocean floors. That the rock underlying the ocean bed was denser than that underlying the continents was a result expected and indeed forecast by other lines of investigation. Equally significant and quite unexpected were the results associated with some of the ocean deeps—Nero Deep, off Guam, for example—and particularly the great troughs bordering the East Indian and the curiously similar West Indian arcs. All of these provided strongly negative gravity anomalies, showing deficiencies of as much as 250 milligals (a milligal being approximately one-millionth of the normal force of gravity) and commonly exceeding 100 milligals. The East Indian strip forms an arc more than 3000 miles long, bordering Sumatra, Java and Timor to the south, swinging back north across Tanimbar and Kei, west past the Moluccas, and away to the north between Celebes and Halmahera. The West Indian arc (Fig. 1), similar in size, bounds the Caribbean from Cuba round to Barbados, then swings west across Trinidad and the north coast of Venezuela, and inland to Colombia.

According to Meinesz and Hess, each of these strips (surprising though it may seem since they are both associated with some of the deepest oceanic troughs) is really an incipient, mainly submarine, mountain chain—a chain on a scale fully comparable in extent with the Andes or the Himalayas. Each represents a line along which the crust has been pulled or pushed down (Fig. 2) so that the contorted, piled-up, and hence thickened selvage of the granitic and intermediate layers has "displaced" the heavier, basaltic material. The formation of this "root" to the mountain chain is the cause of the deficient gravity along the negative strips, and such a structure is comparable with the postulated "roots" of terrestrial alpine chains. In the East Indies, geological formations on the islands

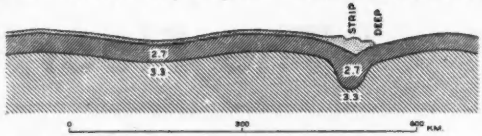


FIG. 2.—Diagrammatic section illustrating the "root" theory of strips of negative gravity anomaly (from Daly, after Meinesz). Granitic layer stippled, the remainder of the solid crust shown with a density of 2.7, resting on subcrustal material of density 3.3.

nearest the line of negative anomaly (such as Tanimbar, Kei and Ceram) are folded and deformed; Trinidad in the West Indies shows overthrusting. In each case, the contortion is late Tertiary in age, and so, incidentally, were the culminating movements that raised the Alps, the Carpathians and the Himalayas. This interpretation is still very much in the stage of hypothesis, but the locating of these negative anomaly strips ranks among the major geological discoveries of recent times.

The relief of the ocean floor thus includes some profound troughs usually referred to as deeps, and not infrequently associated with negative gravity anomalies. It also has innumerable mountains that would be spectacular were they terrestrial features. Many break surface as oceanic islands, rising abruptly from an ocean floor 2000 or 3000 fathoms below; others remain many fathoms submerged, or have been reduced to shoals by marine erosion. They have been built up around volcanic vents as vast cones of basaltic lava. The Pacific Ocean abounds in them and Hawaii is typical; but the Atlantic has its Ascension and St. Helena, and the Indian Ocean its Kerguelen Island and Maldive Archipelago. The source of the magma or molten rock building these localized lava cones is, in the final resort, the lowermost or basaltic layer of the earth's crust; for the mechanism of their extrusion we have several hypotheses, but they are beyond the scope of this article. It may be noted, however, that there is abundant evidence that these volcanic islands are stable, and since they are not compensated by being of lighter rock, it is clear that the crustal layer must have considerable strength.

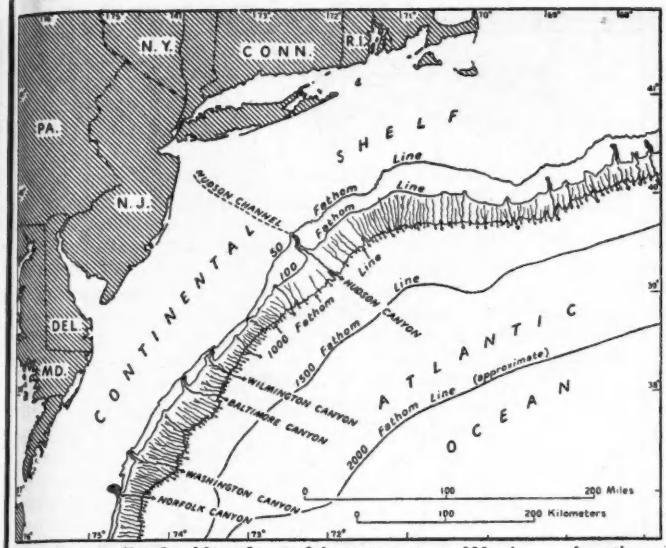


FIG. 3.—Map of part of the eastern coast of North America, showing the continental shelf and the distribution of canyons and slope furrows. From Daly.

Sea Level Changes

Thus far the story has been unified by a concept of earth structure; the remainder of Professor Daly's book, dealing with altogether more superficial features, relates to a different guiding principle but one particularly associated with his personal researches, namely, the lowering of sea-level during the Pleistocene Ice Age. The ice-sheets which developed during the Pleistocene covered an enormous area in North America, Europe and North Asia, and in places attained a thickness of several thousand feet. The volume of water thus frozen was immense; its source must have been the ocean; and it is calculated that the consequent lowering of the sea-level was of the order of three hundred feet.

Under the name Molengraaff River, Dickerson[1] has described a buried channel on the floor of the South China Sea which would be a continental feature were the sea-level lowered by 300 feet, and to it the rivers of Sumatra, Java, and Borneo are the headwater tributaries; and the evidence of the distribution of living animals in this region and in the Phillipines also suggests a recent lowering of sea-level of about this amount. With such a lowering, a considerable proportion of the continental shelves the world over would have been converted to dry land, and the patchy distribution of sand and gravel which so unexpectedly characterises many of the shelf seas suggests that the bottom sediments are often re-worked terrestrial deposits rather than the normal products of a marine environment. In some places, glacial boulders have been dredged, and again—for example off south Ireland—soundings have revealed a buried glacial topography. Had the accumulation of the shelf sediments depended solely upon marine processes, we might have expected the more or less regular zoning from coarse to fine outward from the coast, such as many geological textbooks envisage.

[1] *Shiftings of Sea Floors and Coast Lines.* University of Pennsylvania Bicentennial Conference. University of Pennsylvania Press, 1941. (Oxford University Press, 3*s.* 6*d.*).

Coral Reefs and Canyons

But these are not the only results attributable to glacial lowering of sea-level. Professor Daly has claimed that this lowering was a decisive factor in the development of coral reefs and atolls. Coral islands are often sited where the neighbouring sea is at abyssal depth, yet they are composed, superficially at least, of the skeletal remains of animals that can tolerate only a very limited depth (about 30 fathoms); and consequently their origin is something of a puzzle. Darwin's theory of submergence, whilst adequate to account for the conversion of a fringing or barrier reef to an atoll (which would not necessarily require very great subsidence) can scarcely be the whole explanation of reefs that rise from a sea-floor 2000 or 3000 fathoms below. Murray's theory that they were sited on volcanic islands, built up to within 30 fathoms or less of the surface, has much to commend it. Daly's glacial control theory envisages a repopulation of the shores of all kinds of islands (after the organisms were killed off by cold) as the climate ameliorated, and a raising of sea-level (equivalent in its effect to Darwin's submergence) as the meltwaters of the waning glaciers were restored to the sea at a rate with which coral growth could keep pace.

Professor Daly's last chapter refers in the main to another remarkable and unexpected feature which has become known with the advent of echo-sounding. Echo-sounding is an improvement on the old plumb-line methods chiefly in the speed with which readings may be secured, and hence in replacing scattered spots on our charts by strings of soundings. A few anomalous deep readings near the edge of the continental shelves had long been known; but only as the result of recent expeditions equipped with echo-sounding devices have we become aware of the existence of large numbers of deep "canyons", while the intervening continental slope appears grooved with innumerable minor "slope furrows" (Fig. 3). Much more evidence is wanted, but already we can say that the distribution of these canyons is probably world-wide. Perhaps the most completely explored are the Hudson Canyon (off the mouth of the Hudson River) and the group off Georges Bank on the east of North America, and more recently those off the south-west coast of California (Fig. 4). Their length is often 60 to 80 miles, with a breadth of some 4 to 8 miles and a depth of as much as 4000 feet below the level of the sea floor in between. Their gradient of about 1 in 30 is far steeper than that of any comparable river valley features.

Naturally the origin of such features has provoked considerable speculation, and we are far from a universally acceptable solution. Some writers have suggested that they represent drowned valleys cut by ordinary terrestrial rivers; but the floor of many canyons is some 8000 to 10,000 feet below present sea-level, and no explanation is

forthcoming as to how the enormous submergence required could have been produced. More usually quoted views centre round some form of submarine erosion. It has been demonstrated experimentally that silt-laden water as a bottom current preserves its individuality and does not quickly mix with clear overlying and surrounding water; and also that such a current can erode newly deposited and uncompacted sediment. It may be that, as Kuenen observed, such a current can become self-accelerating and thus "endowed with new self-generating power to erode"—i.e. if it can attain a velocity of only two miles an hour, it will take up additional mud, becoming denser and therefore flowing yet faster down the slope, and so able to erode yet more efficiently. In the view of the protagonists of this explanation, the canyon, given time, erodes itself; and according to Professor Daly, conditions for the formation of such currents were specially developed at certain stages of the glacial period at a time when, by the lowering of sea-level, shore lines stood many miles further out from their present positions towards the edges of the continental shelves. This explanation is perhaps more plausible than the others which have been propounded. But it is not readily acceptable to those, amongst others, who doubt whether at a depth of 4000 or 5000 feet the sediments of the continental shelves remain so unconsolidated as to be susceptible of erosion by such means. For it seems implicit in such a view that unconsolidated sands and muds of presumably recent origin extend down for a thickness of many thousands of feet and thus come to form the sides of these steep canyons. Yet blocks of sandstones of Cretaceous and later age have been dredged from the sides of canyons in the Georges Bank area and are said to have been broken off from outcrop ledges on the sides of the canyons. In Professor Daly's words, "the carving of a complete image of truth about the submarine valleys must be regarded as unfinished business"; here as indeed throughout the book, Professor Daly has told a story of entrancing interest, and the general reader no less than the geologist will be grateful to him.

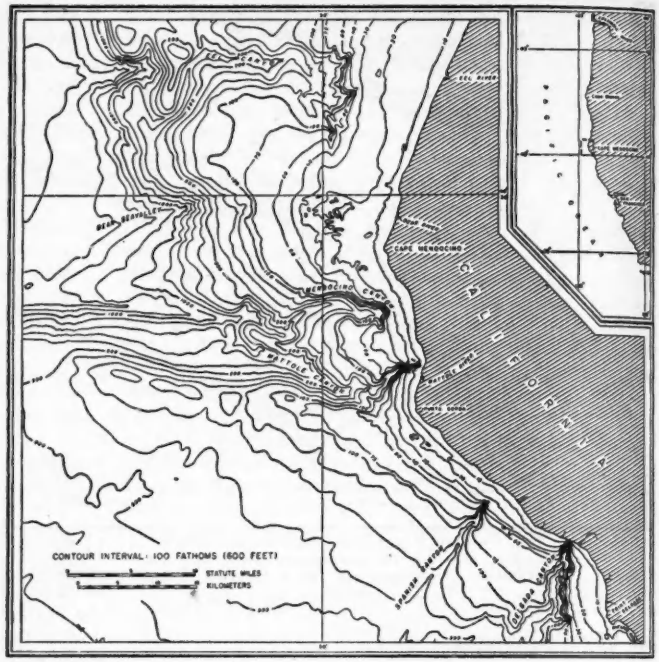


FIG. 4.—Map of the submarine canyons off the Californian coast (from Daly, after U.S. Coast and Geodetic Survey).

PROGRESS OF SCIENCE: DISPUTED TERRITORY (*continued from p. 5*).

It is perhaps significant that Hollander and Claus who carried out the National Research Council survey and failed to detect any sign of the radiation either by biological or physical means, should have emphasised in their report that while Gurwitsch's discovery was not confirmed, it could not be regarded as disproved by their work.

Recently, new interest has been aroused by the discovery that weak ultra-violet radiation is indeed emitted by a number of simple chemical processes such as oxidation and the neutralisation of a strong base by a strong acid. These observations were made under conditions where no mitogenetic radiation seemed likely to be present, and it may be that some of the phenomena listed as due to this radiation may in fact have arisen from such purely chemical sources. In this connection it is interesting to note that "mitogenetic" radiation has been reported as issuing from stimulated muscles and nerves where no rapid cell division is to be expected.

One of the main difficulties connected with the subject has been the explanation of the emission of quanta of high energy from biological processes, a difficulty which may be removed by this new discovery of the emission of ultra-violet radiation during chemical reactions, and which forms the subject of Professor Gurwitsch's latest paper.

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[*The heading to Dr. D. S. Evans's first note in the December issue should, of course, have read, "Beveridge for Science." We regret that a printer's error made it read, "Beverage for Science."*]

In Praise of Statistics: *A First Guide to Quality Control for Engineers:* Ministry of Supply, September 1943. *The Epidemiology of Diphtheria during the last Forty Years*, W. T. Russell, Medical Research Council, 1943. *Memorandum on Official Statistics*, Royal Statistical Society, 1943.

Black Death: *Ergot and Ergotism*, G. Barger, London (Gurney & Jackson).

Entomology: some recent investigations

H. HENSON, Ph.D., F.R.E.S.

At the present time many people besides farmers and entomologists are becoming aware of insects as competitors. Many a would-be vegetable grower has sorrowfully surveyed the damage caused by cabbage root maggot, carrot flies and caterpillars. Nor do insects confine themselves to attacking standing crops, they take stored products, eat our clothes, invade our houses, and in the form of wasps and midges occasionally drive us from our own gardens. Bugs and lice even go so far as to use man himself as their food material.

Dr. A. D. Imms, in his recently published *Outlines of Entomology*[1] informs us that about 700,000 species of insects are known and that perhaps as many again still await discovery. Of this number only a small fraction are really harmful, and even then only when very abundant. The size of an insect population is difficult to assess, but minimum figures can often be obtained. Thus by hand picking it has been estimated that the wireworm (larva of the click-beetle) averages 750,000 to the acre in Kent, 600,000 in the Midlands, and 450,000 in Yorkshire. These figures, of course, apply to grassland areas and work out at about 100 to 150 to the square yard.

The success with which insects exploit their environment depends partly upon structural peculiarities and partly upon modifications of their life history. The more important structural features are small size, capacity for flight, and the presence of a hard external coat or cuticle. Small size enables a whole generation to be raised on a small amount of food, and flight enables all the available food material over a wide area to be found and utilised.

The wings, of which there are usually two pairs, are really nothing more than extensions of the lateral walls of the thorax supported by a system of stiffening bars known as wing veins. During flight the wings not only rise and fall, but move slightly backwards and forwards by the action of small muscles attached directly to their base. On the downstroke the wing moves downwards and forwards with the posterior area elevated, on the upstroke it moves upwards and backwards with the posterior area depressed. "Thus (to quote from the *Outlines of Entomology*) in each complete stroke there is a turning of the wing on its long axis which has a mechanical effect like that of the revolution of a propeller blade." The number of wing beats per second varies in different insects. It is about 190 in the house-fly and hive-bee, about 300 in the mosquito, 28 in dragon-flies, and 9 in cabbage butterflies. The swiftest flying insects are probably hawk-moths and dragon-flies, one species of the latter has been recorded as achieving 90 miles per hour. For perfection of controlled flight however nothing approaches the hover-fly. It can be seen in almost any garden hanging motionless in the air, creeping slowly forwards like an airship or darting swiftly away—it is the perfect model for the "owner driver" aircraft of the future.

[1] *Outlines of Entomology*, by A. D. Imms, D.Sc., F.R.S. (Methuen & Co., 1942; pp. viii + 184 + 96 illustrations, 12*s.* 6*d.*).

The cuticle has in the first place provided armour, then, by moulding it into a system of jointed tubes, efficient legs and mouth parts have been created; by extending it inwards a system of non-collapsible tubes has arisen which penetrate all the tissues of the body and carry oxygen directly to them. There is thus formed a highly efficient respiratory system without the heavy heart muscles which would be necessary to maintain an equally effective blood respiratory system.

Apart from their structural efficiency many insects have developed a specialised type of life history which perhaps is without any real parallel in the whole of the rest of the animal kingdom. All insects during growth cast their skins several times, a process known as moulting or ecdysis. Types such as the cockroach hatch from the egg in a form very like the parents, but with incompletely developed wings and other minor structural deficiencies. Such young stages are called nymphs; they pass through a series of moults and gradually assume the adult form. Flies, bees, and butterflies on the other hand hatch as maggots or caterpillars; these grow and moult, but do not appreciably alter their form until they become full grown, when they change to a pupa or chrysalis. The fully developed insect emerges from the pupa in due course. Such young stages as maggots, caterpillars, etc., are known as larvae. They are distinguished from nymphs by the absence of compound eyes and by the fact that they normally give rise to an inert pupal stage before completing their life cycle and emerging as adults.

Current research in entomology covers a very wide field, and the subjects which follow have been chosen solely because they may be of interest to scientists other than entomologists.

Sewage Flies

Certain kinds of insects have successfully colonised the bacteria beds of sewage disposal plants. The conditions of life in this unusually restricted environment are comparatively uniform. The only weather change of any great variability is temperature, and the number of species competing with one another is sufficiently small for at least some of their mutual reactions to be observed. It thus becomes possible to determine the effect of the total environment on each species, in other words to see a "survival of the fittest" system actually at work.

The crude sewage as it arrives at the works is freed from the grosser solid matters and the resultant liquid eventually passed through sprinklers which spread it over beds of stones (bacteria beds). Here it becomes purified, largely by oxygen absorption, and can then safely be passed into the rivers. In consequence of the abundant moisture and plant food a thick rind of plant growth develops on the stones of the beds. This, largely composed of the blue green alga *Phormidium*, serves as food material for the larva of several kinds of flies and worms. If for any reason the insects or worms are deficient, the plant

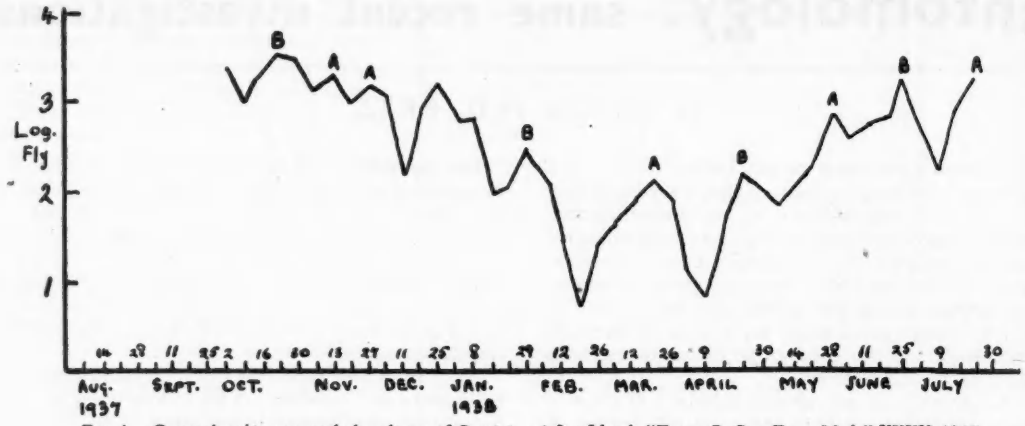

FIG. 1.—Curve showing seasonal abundance of *S. minima* (after Lloyd, "*Trans. R. Soc. Trop. Med.*," XXXV, 1941).

growth develops so strongly as to choke the beds and lead to ponding (as sewage engineers describe it).

The principal occupants of this man-made environment are three species of chironomid midges (*Metriocnemus longitarsus*, *M. hirticollis*, *Spaniotoma minima*), two species of psychodid flies (*Psychoda alternata* and *P. severini*), and an enchytraeid worm (*Lumbricillus lineatus*). The numbers of the different species of flies emerging from the beds each week has been determined by a system of trapping. A typical result for *S. minima* is shown graphically in Fig. 1. It will be seen that the number of flies obtained each week fluctuates rapidly and gives a curve marked by a series of peaks. As will be evident in the sequel this can be shown to be purely a temperature effect.

Laboratory experiments have shown that the life cycle of this *Spaniotoma* cannot proceed at temperatures below 4·5°C., which is therefore known as the threshold temperature. Further, the product of the number of degrees above the threshold and the length of the life cycle in days is a constant whose value is about 450. Thus at 9°C, the life cycle occupies about 100 days, at 15°C. it occupies about 43 days and so on. This product of temperature and time is called the thermal constant; it is usually given in day degrees, and for *S. minima* is fairly accurate between 8°C. and 24°C. It holds good for the average length of the life cycle, although in any one family the period of emergence from the pupa may spread over a considerable period.

By working out the expected length of the life history at the temperatures actually experienced in the beds, it is found that the flies causing peak B on October 23rd (Fig. 1) give rise to generation B on January 29th, and this in turn to that on April 23rd, and so to June 25th. The sequence of B peaks thus represents successive filial generations. The series of A peaks represents another succession of lineal generations but is peculiar in that it begins in a bifid form on 13th and 27th of November. This was due to the fact that the bed on the former date registered 10°C. and on the latter just over 10°C. but in between the temperature fell smoothly to 6°C. and delayed pupal progress and so formed the double peak. If the temperature had not fallen, all these flies would have emerged at about the same time and would have been registered on the curve for November 13th. In March, when the offspring from these two lots were emerging, the temperature was rising steadily so that offspring from the 27th of November gained some days on the offspring from the 13th of November and both lots emerged together to give the peak on March 19th. It is evident that sudden downward changes of temperature split an incidence peak into two separate parts, whilst marked upward changes gather them together.

The kind of theoretical analysis which shows that the occurrence of peaks on the incidence of emergence curve is due to temperature fluctuations can be appreciated by consideration of a number of ideal situations. In the first place if the number of flies emerging each day for 43 days was the same, and the temperature throughout the year was 15°C., each life cycle would occupy 43 days and the incidence curve would be flat topped. Next, suppose that eggs were laid on March 1st and on March 30th, and that the temperature remained at 10°C. throughout March and then rose to 15°C. and thereafter remained constant. The March 30th eggs would require 43 days and would emerge on May 13th. The March 1st eggs would have 30 days at 10°C. and the rest of their cycle at 15°C. That is they would get 165 day-degrees of their thermal requirements at 10°C. and would need 285 day-degrees at 15°C. This means a further 27 days so that they would emerge about April 27th. Thus the two families originally separated by a month are now only separated by about 16 days. It is obvious that if during March the temperature fell for some time below the threshold, the two lots would emerge still nearer together. By a long calculation it can be shown that starting with a uniform flat topped incidence curve, and supposing that temperatures are those actually experienced in the beds, a new incidence curve is obtained remarkably like that given by the trappings.

The competition between the various forms inhabiting the beds is also important in controlling their numerical fluctuations. *M. longitarsus* is one of the main controlling factors. It flies in every month of the year, especially in the winter and again in May. This latter flight establishes

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FIG. 2.—Monarchs hibernating at Pacific Grove in the winter of 1938-39. Photo by J. A. Downes.

its offspring in June. If June is cold and wet this form is successful and a barrage of *longitarsus* larvæ is formed near the surface of the beds. Much egg-laying of the other species takes place in this barrage and the eggs are largely destroyed by the *longitarsus* larvæ. If June is hot the *longitarsus* are destroyed to a great extent—the larvæ cannot live above 20°C., a temperature easily reached on hot days even with the sprinkler working. *M. hirticollis* has a major flight about a month later than *longitarsus* and cannot establish itself unless the latter have been dispersed. *S. minima* is also affected but having a quicker life cycle recovers in the later months.

Butterfly Migrants

Some insects are so successful that their breeding grounds tend to become greatly overpopulated. When this happens migratory swarms may be formed, but it cannot be said that this is connected with food shortage. For instance any single species of locust may occur in two distinct phases, in the solitary phase it is an ordinary grasshopper and remains in its original home. In the gregarious phase which results from breeding in crowded conditions it forms migratory swarms. Butterflies and moths also sometimes form migratory swarms, but in this case the principal aspects of the problem are only just beginning to be studied. The conditions under which migration is initiated, the perceptions by which it is carried out, and the routes followed remain to be determined (Fig. 3).

Most of our own migrant butterflies such as the Clouded Yellows, the Bath White, the Cabbage Whites, the Painted Lady and the Red Admiral seem to reach this country from France, but the Camberwell Beauty is unique in being recorded mostly from the East Coast—suggesting perhaps a Scandinavian origin.

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FIG. 3.—*Eunica minima* migrating in Mexico in June, 1940. Photo by D. B. Legteres.

In the case of the large Cabbage White (*P. brassicae*) there seem to be two migratory seasons, early June and early August. In England the recorded flights are preponderatingly to the N. and N.W. at both seasons, but a fair number of southerly flights have been observed. On the continent the second season gives flights almost entirely to the south.

The Painted Lady (*V. cardui*) frequently occurs in Britain in the spring, but specimens are always faded and ragged in appearance. These seem to come from N. Africa or perhaps even beyond the Sahara and breed with us during the summer. There is no evidence of a return flight in the autumn, but the numbers leaving would in any case be rather too small to be readily observed. In America this species breeds on the west coast of Mexico and flies northwards in spring over much of the northern part of the continent. It is just possible that some of these actually cross the N. Atlantic to Europe because they were seen 500 miles from Newfoundland near the *Great Eastern* when she was laying the Atlantic cable in 1865.

The Great Southern White (*Ascia monuste*) is another American migratory species. In two successive years it has been observed in Florida flying south until about the middle of May and northwards from this time onwards until August. In this case it is highly improbable that the northbound individuals are the same as those which passed south earlier in the year.

The best known of all migrant butterflies however is the Monarch (*D. plexippus*). In autumn there are flights all over the eastern half of the U.S.A. and again along the western side beyond the Rockies. They are known to winter in clusters in trees along the Californian coast. Each cluster is usually composed of a small number of individuals, but a large group of about 10,000 has been observed (Fig. 2). In spring the same individuals fly north again, the only case in which this occurs. The Monarch occasionally appears in England and must cross the Atlantic to do so. However, there is only one old record of its having been seen at sea, and some entomologists think it may possibly be carried in the holds of ships.

In the case of birds much valuable information respecting their migrations has been obtained from ringing experiments. In butterflies no comparable technique has been worked out, and marking experiments have not yielded any real results—apparently only one recapture at a distance has been recorded, a Red Admiral released at Stroud was seen later in Berkshire.

Metamorphosis

The changes of form through which insects pass during growth constitute the phenomenon of metamorphosis. The problem is zoological rather than entomological, and in its simplest form may perhaps be stated as follows. The fly lays an egg; within this a developmental process takes place and a maggot is produced; the maggot grows, but does not appreciably change its form until it enters the

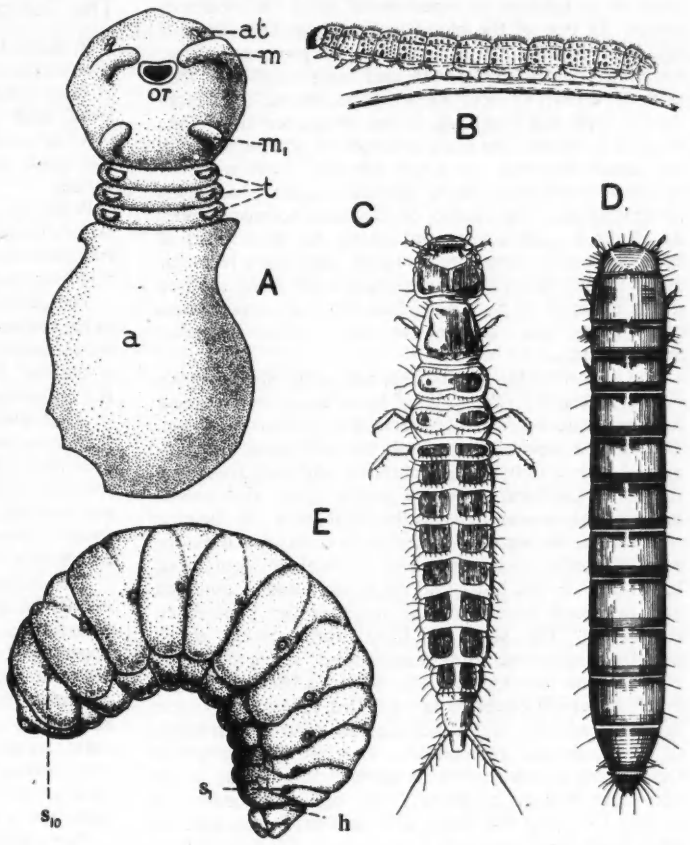

FIG. 4.—Laval Types. A, protopod (Proctotrypoidea). B, polypod (Lepidoptera). C, oligopod (Coleoptera, Staphylinidae). D, do. (*Tenebrio*). E, apodous (Hymenoptera: hive bee). (A *from* Kulagin, E *from* Nelson). *a*, abdomen; *at*, antenna; *m*, mandible; m_1, maxilla; *h*, head; s_1, s_{10}, spiracles; *t*, thoracic limbs; *or*, mouth.

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pupal phase; a renewed development then produces the adult fly. Most animals develop first and then grow, this one grows first and then develops. In other words metamorphosis appears to be the result of interference with the usual relations between growth and development.

Recent work seems to indicate that the developmental cycle which occurs in the pupal phase is fundamentally of the same nature as that which occurs within the egg in the same species; i.e. the developmental processes which occur within the egg are repeated and carried much further in the pupal stage. Furthermore, each little developmental cycle leading to the moulting of larval stages has much the same characteristics. Thus one can imagine the insect life history as a succession of similar developmental cycles, the first occurs in the egg, the next ones at each stage of larval growth, and the last in the pupa. In an insect in which metamorphosis does not occur each of these cycles has the same end result and the life history shows a succession of forms similar to each other, except in size, and not very different from the adult. In insects with metamorphosis the earlier cycles are interfered with to a greater or lesser extent and prevented from achieving their full expression, thus giving rise to a whole series of different kinds of nymphs and larvæ.

The young stages of these metamorphic insects can be arranged in a sequence showing progressive reduction in general level of organisation: (1) the *nymph* (e.g. cockroach) characterised by the possession of compound eyes and a hard, dark coloured cuticle, and by the fact that it approaches the general form of the adult; (2) the *typical oligopod larva* (e.g. rove beetle, Fig. 4 C) with no compound eyes; cuticle well developed and dark coloured; long and strong thoracic legs, and whip-like appendages on the tail (cerci); (3) *the modified oligopod larva* (e.g. caddis fly) with well developed thoracic legs, no tail cerci, and chitinous cuticle strongly developed on some parts of the body but elsewhere somewhat thin and unpigmented; (4) the still *more modified oligopod* with reduced thoracic legs, as in the meal worm (*Tenebrio*, Fig. 4 D); (5) the *grub-like larva* (e.g. the hive-bee, Fig. 4 E) with soft unpigmented cuticle, and no legs, but with the head reasonably well developed; (6) the *maggot* (e.g. blowfly) with no legs, soft cuticle, and the head much reduced and infolded. [In addition to this series there is the *protopod larva* (Fig. 4 A) which is only a precociously hatched embryo and the *polypod* or *caterpillar* type of larva (Fig. 4 B). This latter has some similarities to certain embryonic stages and like the protopod is usually regarded as a precociously hatched embryo; the present writer thinks it may really correspond to the fourth grade of the above series.]

The culminating point of interest about this graded

series is its relation to experimental work on metamorphosis. In one of the blood-sucking bugs (*Rhodnius*) it has been possible to demonstrate the presence of two hormones controlling growth and metamorphosis. One of these, known as moulting hormone, induces a developmental cycle and eventually brings about ecdysis. When it alone is present the cycle proceeds to completion, and the insect develops its adult features—even a newly hatched nymph becomes a miniature adult under such circumstances. The second or inhibitor hormone exerts its effects by checking or inhibiting the developmental cycle, and in its presence nymphal characters reappear at the moult. Even a fully developed adult when exposed to the influence of both hormones will start development once more and acquire at least some nymphal characteristics.

The experimental results obtained with *Rhodnius* can surely be related to the series of larval forms by assuming different degrees of intensity of action of inhibitor hormone. Thus in the case of the nymph the embryonic developmental cycle is only slightly inhibited, and each successive stage is less and less subject to inhibition and thus results in a gradual advance towards the adult form. In the case of the larvæ the degree of inhibition in embryonic development is greater and is moreover maintained throughout larval life. In the last larval stage inhibition is removed and the pupal developmental processes can proceed to completion. The series of larval forms listed above might perhaps be the result of increasingly severe inhibition of embryonic development. In *Meloë* (a beetle) the eggs hatch as typical oligopod larvæ called triungulins; these actively search for and attach themselves to certain kinds of bees (*Andrena*, *Anthophora*). They are thus carried to the nest and sealed up with the egg and stored honey of the bee. The triungulin devours the egg and undergoes ecdysis to a grub-like form with well-developed legs. It then feeds upon the stored honey and develops into a thick-bodied legless grub. In this species the inhibitory influence exerted in the embryonic stage is sufficient to reduce development to an oligopod larva, at the next stage it is more powerful and reduces the development to the grub-like form whilst in later stages it becomes still more potent and causes the production of the legless larva. This retrogression can be compared to the experimental conversion of an adult *Rhodnius* back to the nymph-like form.

Whether the notion that growth is accompanied by a succession of developmental cycles similar to embryogenesis can be extended to animals other than insects is not yet clear. If so insects may supply the clues leading to a much greater understanding of growth in general and possibly point out a new line of approach to the cancer problem.

The Cuticle (*by R. Dennell, D.Sc.*)

In insects the cuticle is found in two apparently markedly contrasting types, the hard dark cuticle characteristic of most adults and the soft white cuticle found in many larvæ such as maggots and grubs. All insects have a soft white cuticle just after a moult, but in the course of a few hours this usually changes to the dark and hard variety.

When fly maggots change to the pupa the last larval skin is retained and rapidly hardens and darkens to form the protective casing known as the puparium, a process involving complex physical and chemical changes.

The larval cuticle is composed of two layers, a thin outer epicuticle and a thick inner endocuticle. The latter is composed of a water soluble protein containing crystallites of chitin dispersed at random within it. Chitin is a nitrogenous polysaccharide with the empirical formula $(C_8H_{13}O_5N)x$. As this cuticle hardens to form the puparium the protein becomes largely insoluble and more intimately associated with the chitin; at the same time the chitin crystallites become orientated to lie parallel with the surface. The water content diminishes and as a result of these changes the cuticle becomes more compact and harder.

The darkening of the cuticle, which is accompanied by further hardening, takes place at the outer surface of the endocuticle and extends progressively inwards. This appears to be due to the conversion, by enzyme activity, of aromatic substances derived from the blood into coloured oxidation products and ultimately to melanin or allied substances. Simultaneously the protein is "tanned" by these aromatic substances owing to the introduction of cross linkages into the protein network. This outer dark zone of the endocuticle is thus differentiated as another layer and is known as exocuticle.

The endocuticle is traversed by fine vertical vessels the pore canals which continue on through the exocuticle if this layer is present. In the larva of the flesh-fly, *Sarcophaga*, these canals contain chitinised filaments coiled in the form of a helix as shown in the photograph taken from an actual specimen (Fig. 5). Canals of similar form but not filled by chitin, and of much smaller size, have been observed by means of the electron microscope in the cockroach cuticle.

The thin epicuticle about which much less is known plays a great part in controlling the permeability of the cuticle. It is chemically very stable, perhaps because of the presence in it of highly polymerised lipoids. It is not penetrated by pore canals.

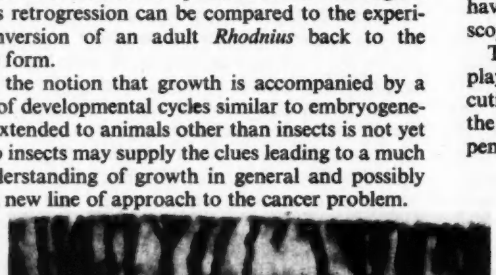

FIG. 5.—Section through the cuticle of larva of *Sarcophaga* showing pore canals with chitinous contents.

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The Bookshelf

The Economist, 1843-1943. By Geoffrey Crowther and others. (O.U.P. 1943; pp. iv. + 180 + 2 plts.; 7s. 6d.).

This surely is an important little book. It will be read with interest and profit by editors, by students of political economy and economic history, by discerning and informed business men, by Government officials and by politicians alike.

For this centenary volume, though produced in war-time and so of necessity a "modest memorial", provides us with a feast of good things, the most appetising and nourishing of which is the first chapter, written by the present editor. All editors of journals of opinion will relish this chapter. It tells in pointed style and polished phrase of an editor's common anxieties, limitations, technique, duties, and opportunities to fashion, as well as to inform, public opinion. The duties of such an editor are particularly subtly emphasised. In the light of his general remarks, the writer then passes under review the abiding ideas behind the general policy of *The Economist* during the last one hundred years. This journal has held to its opinions clearly and fearlessly, but has had few prejudices of any kind and no party prejudices at all. It has unfailingly supported the great ideal of liberal thought, regarding as the test of freedom "not absence of constraint so much as the presence of consent". Equally *The Economist* has always concerned itself with the interest of "the whole people, rich and poor, town and country, capitalist and labourer". Further, it has ever been internationalist in faith. A philosophy founded on such principles has naturally been growing and progressive in its content: indeed, in its pages, judgment and reason have played increasing, and doctrine and dogma diminishing, parts. More might easily be said about this instructive and epigrammatic declaration of an editor's faith. But perhaps enough has been said to make it manifest that in Geoffrey Crowther *The Economist* has to-day an editor worthy to follow in the tradition of Wilson and Bagehot, Hirst and Layton.

Point and further substance are given to the editor's chapter by the deputy-editor who engagingly writes of the character and outlook of former editors of *The Economist*. He makes it plain that the journal has had, and still has, a political and general, as well as an economic, side, and that its world-wide reputation has been solidly built on anonymity and independence of its articles, and on the tradition of its integrity and personality, strong and unambiguous.

Nor is the more general student of the Victorian period forgotten. Dr. Clapham's treatment of *The Economist* as a source for the historian is full of valuable ideas and fragments of information. While E. L. Woodword, in his "Political Retrospect", has written a chapter, that is as easy to read as it is informative, on a challenging selection of political and other issues. F. W. Hirst writes of that Victorian giant Bagehot, who took nearly all knowledge for his province, and who shone as a banker, an economist, a man of letters, an editor, a conversationalist. No wonder Gladstone consulted him freely on budgetry and currency problems; no wonder he left a stamp upon *The Economist* that is still discernible. And Graham Hutton is equally happy when telling of *The Economist's* sustained interest in foreign affairs, which explains why from the outset its circulation abroad has formed a large percentage of its total sales —almost 50% by 1939.

More technical chapters deal with the Money Market, the Stock Exchange, Records and Statistics, and Bagehot and the Trade Cycle. Each is well written, especially that on the Stock Exchange; each has a bearing on the structure of *The Economist* of to-day and on current economic problems. Modern students of Full Employment, for instance, will especially wish to study the last chapter.

It is a far cry from the days of the young Gladstone and the Anti-Corn-Law League to those of Winston Churchill and the Beveridge Report. But, if Wilson and Bagehot could see *The Economist* to-day, they would be proud of their lusty and enlightened and influential offspring. Assuredly, in this case, "a centenary is a milestone, not a terminus." R.W.J.

Basic Radio. By C. L. Boltz. Nelson's Aeroscience Manuals. (Nelson, London 1943; pp. vii.+ 271, with diagrams 5s.)

The recent publicity given to Basic English has caused some controversy over just who is supposed to benefit by it, and Mr. Boltz's manual raises the same sort of question. The book may be divided into three parts. In the first the elementary laws of electricity are introduced; in the second the phenomena which form the basis of radio are described; and finally the actual applications of these phenomena are outlined—all this in the compass of some 260 pages. The question arises because it is clear that if the reader needs the first part then the third will prove very difficult to him, whereas if he appreciates the latter, the first part will be superfluous and the second will suffer from lack of space. The answer to the query is equally clear; it is the second reader who will gain most from this book, for the last part is excellent. The circuits of the various fundamental types of amplifier, receiver and transmitter are clearly set out and their practical defects and limitations explained with reference to simple experiments. These do not require more apparatus than can easily be collected by a small class.

One hopes that the publishers will add to their series a separate manual to cover the ground of the elementary section more fully, for the introduction of the first principles of any science deserves all the space that can be given to it. Irreparable harm can be done if the presentation of these ideas fails to be completely satisfying to the uninitiated reader. Mr. Boltz, for example, shows how to trace out the lines of force surrounding a magnet with a small compass needle. He then states that the number of these lines per unit area is a measure of the flux density. But it will be obvious to the student who has just mapped the field that the number of lines depends on the number of points from which he chooses to start his traces. Here is an inconsistency which remains unresolved in the text since there is no subsequent definition of the units involved. The concepts of lines of force and magnetic flux are among the most important and most difficult to grasp in the whole subject of electricity, and consequently require very careful presentation to avoid misconceptions. Inconsistencies such as this, even if swallowed whole at the time, are sure to cause mental indigestion at a later stage. There are, however, many good points about the treatment throughout the book. Emphasis is laid on experimental facts rather than academically formal laws, and such practical tools as the nomogram are introduced at an early stage.

On the whole the diagrams and graphs are good and there are very few printers' errors. Each chapter is concluded by a stimulating set of problems. As a class book for students with a knowledge of the fundamentals of electricity, it can be strongly recommended. C.G.A.H.

Aerodynamics of the Aeroplane. By W. L. Cowley. Nelson's Aeroscience Manuals (Nelson, London; pp. vii + 201 + illusts.; 5s.).

In his preface the author states that this book has been written for students who have reached matriculation standard, but the treatment of the subject is complicated and jerky, and the author gives the impression that he is skipping through those things which should be very carefully explained to the new student, in order to reach the last two chapters which occupy one-third of the book with "complex subjects which may prove difficult and may be overlooked by the beginner."

The layout of the book is not orderly; many of the statements are very badly expressed and the author seems loth to use diagrams to illustrate his points, a weakness in a book dealing with a subject as difficult as aerodynamics.

If an author sets out to write an instructional book for a stated class of reader he should keep this firmly in mind whilst writing, and if he falls to the temptation to deviate, then he should modify his statement of objective.

I would not recommend this book to a matriculation-standard student who was a newcomer to aerodynamics, because he would find his subject very difficult and would become disheartened. A more advanced student who possesses sufficient knowledge to allow him to discriminate will find that parts of this book are quite useful and may add to his knowledge. D.H.S.

Junior Science—Answer—(see p. 8)

A looking-glass is silvered on the back, so that any rays which it reflects have to pass through a layer of glass. Ordinary light gets through; infra-red rays are stopped.

Far and Near

A London Centre for Science

In his presidential address to the Royal Society, Sir Henry Dale spoke of the need for a scientific centre in London large enough to accommodate all the major scientific societies. He called attention to the overcrowding in Burlington House, and instanced the case of the Chemical Society which had to be content with the poorest allotment of rooms; at the time that society moved into Burlington House it had only 450 members, to-day there were 5000; its important library had burst the bounds of its accommodation and part of it was now deposited in the crypt of a neighbouring church. "On all hands we hear talk of reconstruction and see plans for the rebuilding of London," said Sir Henry. "We cannot expect another Christopher Wren—one of our original fellows and a leader in the science of his day; London missed that opportunity. It is natural and proper for the plans . . . to make spacious and impressive provision for opera, drama, music and all the fine arts. But I do not think that we must stand by and allow the claims of science again to go by default. If necessary we must be ready to remind all who may be concerned of the part which the British scientific effort has played in making it possible now to plan at all for our own civic and national reconstruction. But for science, we may remind them, the very different plans which our enemies were so recently making for our future might already be taking effect. I have no doubt that the claim will be handsomely admitted; but we ought not to be too easily appeased with compliments and oratorial bouquets."

Science Deputation to Government

On December 15 the Parliamentary and Scientific Committee sent a deputation, led by Lord Samuel, to Whitehall, where it was met by Mr. Attlee (Deputy-Prime Minister), Sir John Anderson (Chancellor of the Exchequer), Lord Cherwell, Sir William Jowitt, and Mr. Tom Johnston. The invitation to the committee to send a deputation arose directly from the publication of the committee's report on scientific research in the post-war universities.

Fourteen members of the committee took the opportunity of making brief speeches in which they urged the adoption of the recommendations contained in the committee's recent report on scientific research in the post-war universities. For instance Mr. E. W. Salt, chairman of the committee, specifically asked that the universities should be given an additional grant of £1,000,000 for the extension of research and training facilities, and that the Government should allot a day for a House of Commons debate on science and the future of industry. Mr. Attlee replied that he believed that the Treasury was "sympathetically inclined" on this matter. Plans for science, both fundamental and applied, held a high place in the minds of all members of the Government. Sir John Anderson said he would welcome concrete recommendations before the Budget about the effect of taxation on private industrial research. Arrangements had already been made to reconstitute and enlarge the University Grants Committee. It was in the interest of the Treasury that research should be encouraged in so far as it would increase the wealth and efficiency of industry.

B.A. Deputation to B.B.C.

On December 14 a deputation from the British Association visited Broadcasting House to urge a demand for better and more frequent scientific broadcasts. The members of the deputation were Sir Richard Gregory, president of the British Association, Sir Richard Paget, Dr. Julian Huxley, Colonel Mervyn O'Gorman, Professors F. T. Brooks and Allan Ferguson, Dr. D. McClean, Mr. Ritchie Calder and Dr. O. J. R. Howarth.

Readers will recall that at the British Association conference on "Science and the Citizen" (Discovery, April 1943) it was advocated that a permanent committee of scientists should be set up to advise on and to develop ideas for radio programmes, and that this committee —with objects similar to those of the B.B.C.'s committees concerned with music and religion—should have a science programme officer attached to it to maintain liaison between the committee and producers. These two suggestions, it is understood, were discussed last month between the deputation and the Director-General of the B.B.C.

Colonial Products Research Council

The first interim report of the Colonial Products Research Council, which was set up early this year, is published in the Progress Report (1942-43) of the *Colonial Research Committee* (H.M.S.O., 6*d*.). The Council's director of research, Professor J. L. Simonsen, has been found accommodation at the Imperial Institute, where he will have at his disposal the Institute's great store of information on colonial products. The Council has already initiated research into certain commodities upon the direction of which very large numbers of colonial peoples depend for their livelihood; in order to get this work started the Council is making the fullest use of existing research facilities in the universities and other institutions. Research into cane sugar and its derivatives, for instance, has been "farmed out" to the University of Birmingham, where it will be the concern of Professor W. N. Haworth's department. Other substances being investigated include *eugenol and isoeugenol*, constituents of clove oil and other essential oils (University of Durham, Professor R. G. Clemo); *lime oil, lime juice and citrus* (Imperial College of Science, Professor I. M. Heilbron); *fixed oils and fats* (University of Liverpool under Professor T. P. Hilditch, and the Lister Institute under Dr. Ida Smedley-MacLean); *caffeine and theobromine* (University of Manchester, Professor A. R. Todd); *petroleum products* (Dyson Perrins Laboratory), Sir Robert Robinson in consultation with the research department of Trinidad Leaseholds, Ltd.); *ergosterol* (Chemical Research Laboratory of the D.S.I.R., under Dr. A. C. Thaysen). This list is not exhaustive, as the details of certain other researches have to be kept secret for the present.

Mineral Deficiencies in Plants

Plant nutrition depends to a considerable extent upon the composition of the soil, and while several plant nutrients are essential for normal plant growths, soils are most likely to be deficient in one or more of four, namely calcium, phosphorous, potassium and nitrogen: it has long been recognised that deficiencies in these elements will cause malnutrition in plants. Thus has arisen the artificial fertiliser industry, which supplies for farmers compounds containing one or more of the above named elements. Rarely are the other elements essential for plant growth present in such small quantities as to produce malnutrition, but occasionally such things as iron, boron or copper, normally in sufficient quantities in the soil to satisfy the needs of many generations of farmers, are absent and plant growth suffers in consequence. In fact, the absence of these minor or trace elements, as they are sometimes called, may cause complete failure and the importance of minor elements seems to have become greater during the war when the Government's Grassland Ploughing Campaign has brought under the plough many thousands of acres never previously cultivated. All the more important therefore is the early and accurate detection of deficiencies of these minor elements.

Fortunately plants exhibit fairly clearly defined symptoms according to the deficiency of each mineral and these symptoms have been collected by T. Wallace of the Long Ashton Research Station, and beautifully portrayed in colour photography in the *Diagnosis of Mineral Deficiencies* (H.M.S.O., 10*s*.).

Deficiencies however in the major elements like calcium are more frequently encountered and calcium deficiency is extremely important. It is disclosed for instance on sugar beet and mangolds by a ragged scorched effect on the leaves which tend to roll towards the upper surface; phosphorous deficiency is well marked on cereals and is distinguished by the dark bluish-green colour of the leaves and stems, later developing strong purple tints. These deficiencies of the major elements have long been recognised, but those of the minor elements only more recently. Of these deficiencies iron, manganese, boron, zinc and copper are perhaps the most interesting. Boron deficiency is responsible for a large number of so-called diseases; heart rot of beet and mangolds, brown heart of swede turnips and other diseases of cauliflower, lucerne and celery, apples, citrus and tobacco. Truly wide are the ramifications of boron deficiency. Manganese deficiency too has considerable economic importance causing grey

speck in oats, and speckled yellows in sugar beet, considerably reducing the yield of both crops. Recognition of soil deficiency is, of course, possible by soil analysis and field trial, but visual diagnosis is both quick and certain in the hands of a trained observer. Some caution is, however, necessary, for although most of the signs of deficiency are unmistakable confusion is possible. Heart rot of sugar beet may be confused with downy mildew caused by a fungus—Peronospora Schactii. Frost damage may produce symptoms similar to nitrogen and phosphorous deficiency, water-logging may cause a marginal scorched appearance like potash deficiency and potato eel worm can be confused with nitrogen deficiency. Diagnosis by visual methods, now very considerably assisted by Wallace's book and photographs, is sufficiently exact to be of very considerable assistance in farming practice. It often enables the diagnosis to be made and the cure effected during the growth of the crop. Boron deficiencies in sugar beet, for instance, can be met by applying 20 lbs. of borax per acre to the growing crop. Similar deficiencies of other minor elements once disclosed can be put out of action by appropriate application of the deficient element before the next crop.

Even greater strides, however, have recently been made in curative measures, with great economy in material. Now it is possible, for instance, to cure manganese deficiency by spraying the growing crop with a solution of manganese salts. The introduction of spraying methods has indeed considerably improved the control measures which are sometimes ineffective when the deficient mineral is applied to the soil in solid form. The application of iron solids to the soil, for example, is usually ineffective, due to other complicating soil factors, but spraying with a .2 to 1% solution of ferrous sulphate is nearly always economical and effective. In contrast, however, solid compounds of iron can be injected into iron deficient fruit trees and produce a very effective corrective.

University Grants Committee

THE membership of the University Grants Committee has been increased to 15. Before the war the committee numbered 10, but had been reduced by deaths and resignation to five immediately before the appointment of the new members. The following is the list of members:

Chairman: Sir Walter Moberly, D.S.O., Litt.D. *Members*: Dr. E. A. Benians, Litt.D.; Professor W. E. Collinson, Ph.D.; Sir Charles Darwin, K.B.E., M.C., F.R.S., Sc.D.; Miss Margery Fry, LL.D.; Sir Robert Greig, M.C., LL.D., D.Sc., F.R.S.E.; Professor A. V. Hill, F.R.S., LL.D., D.Sc., M.D., M.P.; P. D. Innes, Esq., C.B.E., D.Sc.; Sir Frederic Kenyon, G.B.E., K.C.B., D.Litt., LL.D.; Professor P. S. Noble; Principal Andrew Robertson, F.R.S., D.Sc.; Professor E. J. Salisbury, C.B.E., F.R.S., D.Sc., F.L.S.; Professor J. C. Spence, M.C., M.D.; Professor H. H. Tawney, Litt.D., F.B.A.; Sir Henry Tizard, K.C.B., A.F.C., F.R.S., P.R.Ae.S., F.Inst.P.

"Speech on Light"

DETAILS have recently been published (D. Gifford Hull; *Electronic Engineering* 16, 185, 1943) of an ingenious field telephone device which is believed to have been in use by the German Army since 1935. The complete apparatus was captured at Alamein in 1942. The principle, which is not original, is the transmission of speech by means of a light beam which varies in intensity in accordance with the vibrations of the voice. The ordinary sound film projector uses a device similar to the receiver of the apparatus. It provides a means of communication between two points in sight of one another separated by about five miles, the actual range being somewhat dependent on weather conditions. Its chief advantage over short wave wireless telephony is that the signals cannot be picked up by the enemy, while the absence of wires is a great advantage over the normal field telephone. The whole equipment for each station can be carried by one man. The modulation of the light beam is effected by reflecting it from the internal face of a large prism before projection to the receiver. At the point where this reflection takes place another smaller prism is pressed against the large one by a metal armature. When the pressure is great, part of the beam passes through into the small prism instead of being reflected at the interface, thus reducing the intensity of the reflected ray. The armature is made to vibrate by amplified voice currents from a hand microphone and the resulting alterations in pressure between the two prisms modulate the reflected light beam. The receiver, which is aligned in the direction of the transmitter by means of a built-in telescope, simply consists of a photocell on which the light falls and a two-stage amplifier of normal design. Infra-red filters are fitted so that the beam can be made invisible at night, and this is also an advantage in increasing the range in mist or fog. The optical work on which the success of the apparatus depends is made by Carl Zeiss.

Butter for Hot Climates

DESCRIBED as one of the major food discoveries of the war, Tropical Spread—a butter that will not melt in tropical heat—is not only of value to the troops in Northern Australia and New Guinea, but it also promises to provide an amenity for those who take up civilian life in these areas in peace-time. Where the ice-chest or refrigerator cannot be used Tropical Spread fills a real need. It is a first-class butter, rich in flavour, and spreads easily but remains firm despite high summer temperatures, is free from chemical adulteration and it is far richer in butterfat than ordinary butter.

For more than a year Dr. Wiley and Mr. Loftus Hills, with a band of workers, experimented in the laboratories of the Australian Commonwealth Council for Scientific and Industrial Research. The Queensland Butter Board acted in close collaboration with them, trying out on a commercial scale their laboratory formulæ.

In February, 1943, the first commercial batch of Tropical Spread was manufactured in the production plant provided by the Butter Board, and samples from this trial batch which were sent to troops in New Guinea and Northern Australia, were approved.

The spread is obtained by dehydrating creamery butter and extracting from it the pure butterfat. The butterfat is boiled, and to it is added a small quantity of salt, skim milk powder, flavouring, and 19% of hydrogenated butterfat to increase the melting point to 105°F. The finished mixture is then packed in 1 lb. or 5 lb. cans, and sealed under vacuum.

Personal Notes

DR. ALEXANDER FLEMING, Professor of Bacteriology, London University, discoverer of Penicillin, and PROFESSOR H. W. FLOREY, who rendered great service in the preparation of the drug for medicinal purposes, last month jointly received the award of the American Pharmaceutical Manufacturers' Association for contributing most to the advancement of medicine in 1943.

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MR. H. F. WITHERBY, the well-known ornithologist, died at Chobham last month at the age of seventy. Many years ago he endowed the British Trust for Ornithology with the proceeds from the sale of the bird skins which he had collected in many parts of the world. He was responsible for starting the "British Birds" scheme for ringing birds to trace their migratory movements, and his publications included the familiar *Handbook of British Birds*.

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PROFESSOR J. L. WITTS (Nuffield Professor of Clinical Medicine at Oxford) and PROFESSOR J. R. LEARMONTH (Professor of Surgery in the University of Edinburgh) have been appointed members of the Medical Research Council.

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COLONEL ROBERT JAMES VALENTINE PULVERTAFT, whose signature was on the Prime Minister's health bulletins, is an Assistant Director of Pathology and Officer Commanding the Laboratories in the Middle East. He had been in charge of the laboratories at Westminster Hospital, and was lecturer in the University of London. He was educated at Westminster School, took honours at Cambridge and passed out at St. Thomas's Hospital as University Scholar. He was for a time editor of DISCOVERY.

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DR. C. F. TOY has been appointed Director of the British Cotton Research Association's Research Station at the Shirley Institute, Manchester. He succeeds Sir Robert Pickard, D.Sc., Ph.D., F.I.C., F.R.S., to whom he has been Deputy Director for the past thirteen years.

A School of Aeronautical Science?

IN the House of Commons last month Sir Stafford Cripps stated that he had appointed an interdepartmental committee, under the chairmanship of Sir Roy Fedden, to prepare and submit

detailed proposals for the establishment of a School of Aeronautical Science, as recommended by the Aeronautical Research Committee.

Cure for one form of Cancer

THE cure of cancer of the prostate by treatment with the synthetic sex hormone, diethylstilboestrol, was announced by Professor E. C. Dodds, Courtauld Professor of Biochemistry, London University, at the annual general meeting of the British Empire Cancer Campaign in London last month. He said that in America during the last year or so they had reported descriptions of the treatment of this terrible disease by the administration of this substance by the mouth, and the subsequent complete disappearance of symptoms without any other treatment. The American work had been completely confirmed and for the first time in the history of mankind it was possible to state that one form of cancer could be completely controlled and the patient rendered symptom-free by the administration of a few pills by mouth each day. "We can as a nation take a certain credit to ourselves in this discovery, for while the actual observations of the cases of malignant disease were made by our American colleagues, the weapon which they used was forged directly under the influence and with the support of the British Empire Cancer Campaign," he commented.

Stilboestrol, it may be added, was first synthesised by Professor E. C. Dodds, Sir Robert Robinson, W. Lawson and L. Goldberg.

Malaria in the Army

THE armies of the United Nations have just established their first malaria school overseas in the University of Algiers. Head of the new institution is Colonel Paul Russell, an expert on malaria control and formerly a field director of the Rockefeller Foundation in Malaya and the Near East.

At the opening of the school it was stated by an army spokesman that malaria had caused more casualties than had bullets during the Sicilian campaign, and that it was not until many battalions had experienced serious casualties that commanding officers began to realise the value of atebrin, the synthetic substitute for quinine.

Veterinary Research

THE Wellcome Foundation has acquired the Ely Grange Estate, at Frant in Sussex, for a wide extension of the veterinary research work at present carried out at Beckenham. The new venture will be known as the Wellcome Veterinary Research Station, but it will not come into full use until after the war. It is intended to establish a number of pure lines of animals for experimental purposes, and to do much work on the genetic principles of cattle breeding. The resident veterinary surgeon will be Mr. S. L. Hignett.

Blackening of Cooked Potatoes

SOME potatoes, when cooked, show an undesirable ability to turn black, and this phenomenon has received some attention during the war, both by chemists and agricultural scientists. Experiments described in the *Journal of the Ministry of Agriculture* (December 1943, p. 425), by Dr. T. Wallace and Dr. R. L. Wain of the Long Ashton Research Station, Bristol, suggest that the blackening of cooked potatoes may be due to deficiencies of potash or phosphate in the soil on which the crop was grown. Two years ago U. M. Robison adduced the blackening phenomenon to the formation of ferric iron, probably as the black oxide; the precursor of the black pigment is regarded as likely to be ferrous iron in loose combination with proteins which are decomposed on boiling probably to the hydroxide which is subsequently oxidised. The lack of potash and of phosphate in the soil evidently result in the accumulation of iron in the potato tuber.

South American Science News

THE August number of *Ciencia*, the scientific journal published in Mexico, has an interesting first part of an article on Viruses by Professor B. F. Osorio Tafall, of the Mexican National School of Biological Sciences. It is mainly a survey of work already done, but it provides a most useful contribution to the literature on viruses. An article on the Colombian *chite*, a plant belonging to the *Hypericum* genus, will interest botanists. An inquiry into the content of Vitamin C in Mexican legumes and greens by Professor F. Giral and C. S. Alvarez provides a useful analysis. These articles are perhaps the most important in this issue, but the usual *Noticias* and applied science section contain their customary news from the South American scientific front.

According to the Office of the Co-ordinator of International American Affairs, the Mexican Bureau of Fisheries has sent a small floating laboratory to the river port of Suchiate in the State of Chiapas in order that a thorough study may be made of the habits of alligators, and the industrial products that might be obtained from them. The roaming scientists will devote particular attention to the breeding and feeding habits of these reptiles and will select specimens for distribution in those parts of the country where the beasts are almost extinct. In charge of the research team is Dr. Angel Martin de Lucenay, a biologist.

Science in Adult Education

THE Annual Report for 1943 of the Workers' Educational Association offers some noteworthy statistics on the educational interests of 72,955 adults attending classes arranged by that Association. The study of international relations attracted adult students to 22.35% of the 4,009 classes held in Britain. Literature and drama was next in favour with 12.72%; music followed with 8.58% psychology and reconstruction bracketed with 7.73% and 7.28% respectively. Political and social problems come next with history, each with just over 6%. Then follows economics, social science, and a wide range of subjects claiming between 1% and 3% of the classes. Among these are biology and physiology with a 2.75%; general science with 1.22%; anthropology and human geography 0.68%; and geography (including economic geography) 1.30%. It will be seen from this analysis of the W.E.A. activities that a great leeway in the education in science of the adult population of the country has yet to be made.

Industrial Health and Lighting

DURING the war there has been much evidence that the results of research into industrial health are still not widely enough known and applied. Although a scientific record of the results of research is always necessary, there also appears to be a need for publications, written in non-technical language, which can be readily understood by directors, works managers, workers' representatives and workers.

The present series of pamphlets, of which *Ventilation and Heating: Lighting and Seeing* (H.M.S.O., 3*d*.), is the first, are not intended for experts; they have been written in order that the main facts discovered by research workers may become common knowledge to any interested person in industry, whether manager or worker. It is felt that a fuller understanding of industrial problems is the best basis for any action to improve working conditions in the interests of health and production.

Bibliographies from Spain

Two further volumes of the *Bibliotheca Hispana* have reached this country, and they maintain the interest and usefulness of the initial tome. The volume published in March deals with philology, literature, geography, history and the arts. In this particular number there is a long appraisal of the place that geography occupies in modern academical studies. One cannot help feeling, however, that the work of British geographers is not adequately represented in Senor Jose Maria Martinez Val's survey, nor in the list of 133 books given under the subject-heading Geography. Only 6 English book titles are mentioned there. This, of course, may not be the fault of the writer of the survey or compiler of the bibliography. What the number of British books finding their way into Spain is, it is not easy to assess. The April volume deals with general subjects, bibliography, religion, philogophy, pedagogy, statistics, sociology, and politics, economics, and law. It is the second volume of this group of subjects.

Additional Petroleum from Canada

UNDER the direction of the United States Army Command, drilling has proved an oil-field of considerable future as well as importance, about 50 miles north of Fort Norman in Canada's north-west territories. According to the official statement, most, but not all, of the new wells drilled have produced oil, and further drillings and explorations are now under way. The pipe-lines, from the producing area to Whitehorse (Yukon Territory), where refining facilities have been provided for military and other needs along the Alaska highway, is nearly completed.

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EDUCATION
HANDBOOK

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ILFORD PRODUCTS
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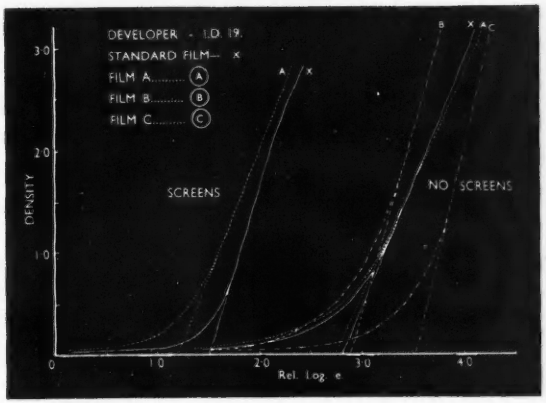

THE need of Industrial Radiography to-day is for a range of sensitised materials varying in their characteristics according to the work to be done. Ilford Limited have met this need with 3 distinct types of X-ray films which fully cover every requirement. A description of these films is given below.

The diagram above shows the characteristic curves of these films in comparison with Ilford Standard X-ray film used in medical radiography.

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An exceptionally fast screen film which can also be used without screens or with metal screens—a truly "general purpose" film, suitable for the radiography of all structures from the lightest to the heaviest whether with X-rays or Gamma rays.

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Aspects of an Industry

BEASTS OF THE FIELD

THE British are a race of animal lovers. A sick beast is a matter of active concern. War has starkly reminded everyone in Britain of the close connection between the healthy man and the healthy animal. To-day the well-being of every man, woman and child rests in part on the health of our livestock. Healthy cattle mean more and better meat, milk and butter ; healthy sheep and lambs, more wool and food; healthy pigs, more bacon ; fit poultry, more eggs ; and horses sound in wind and limb mean more work on the farm. The maintenance of good health and the prevention of disease amongst farm animals are thus vital. Under the spur of necessity British veterinary medicine is playing an essential role in the national economy. Although the subject of veterinary science was studied in some continental cavalry schools in the fifteenth century, it was not until 1790 that a veterinary college was established in London. The great advances made in preventive medicine in the nineteenth century were a stimulus to a similar attack on the scourges to which animals are subject. The results are seen to-day in the way many diseases have been eliminated or brought under effective control. In the British Isles rinderpest, the cattle plague that kills millions of beasts in Europe and Africa, does not now exist. Glanders of horses is rare. The deadly rabies, so often transmitted to Man by the bite of a mad dog, belongs to the past. Anthrax is no longer a farmer's nightmare. Destructive diseases of sheep and lambs due to gas gangrene bacilli can be prevented and cured. Foot and mouth disease is better under control than anywhere else in Europe. But these achievements, great in themselves though they are, are no more than a beginning. The fight must go on against tuberculosis, contagious abortion, mastitis, sterility, and ill-health due to parasitic worms—diseases which have been estimated to cost the farmer twenty millions sterling a year ! In the era of preventive animal medicine, now opening, synthetic organic chemicals will play a decisive part. The worker in the biological research laboratory and the chemist in the factory are uniting to help the veterinary profession to control the diseases of animals and thereby to sustain the health of the Nation.

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